ANNUAL REPORT

OF THE

COMMISSIONERS OF INLAND FISHERIES

1901.

State of Rhode Island and Providence Plantations.

THIRTY-SECOND ANNUAL REPORT

OF THE

COMMISSIONERS OF INLAND FISHERIES

Compliments of the

Commissioners of Inland Fisheries.

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1902.

COMMISSIONERS OF INLAND FISHERIES OF RHODE ISLAND.

J. M. K. SOUTHWICK, *President*.....Newport, R. I.
HENRY T. ROOT, *Treasurer*.....Providence, R. I.
WM. P. HORTON, *Secretary*.....P. O. Box 966, Providence, R. I.
CHAS. W. WILLARD.....Westerly, R. I.
ADELBERT D. ROBERTS.....P. O. Box 264, Woonsocket, R. I.
WM. H. BOARDMAN.....Central Falls, R. I.
ALBERT D. MEAD.....Brown University.

REPORT.

To the Honorable the General Assembly of the State of Rhode Island and Providence Plantations, at its January Session, 1902:

The Commissioners of Inland Fisheries herewith present their annual report for the year 1901:

The work undertaken by the commissioners during the past year may be tabulated as follows:

First. The stocking of our ponds and streams with suitable fresh-water fish, through the distribution of eggs and fry.

Second. The collection of definite data respecting the times of arrival and departure of various food-fishes, and the preparation of statistics of exportation.

Third. The location of fish-traps within the waters of Narragansett Bay, and the collection of statistical date bearing upon their ownership.

Fourth. Experiments resulting in a new method of hatching flat-fish eggs.

Fifth. Further investigation of the red-water plague.

Sixth. The continued examination of the physical and biological conditions of the waters of the Bay, begun in 1898.

Seventh. A continuance of the survey of the shores of the Bay, for the purpose of determining those portions which are most productive of young seed-clams.

Eighth. A continued investigation of the life-history of the clam. Methods of artificial propagation and cultivation.

Ninth. Experiments in lobster-culture.

Tenth. The efforts of the commission to prevent the illegal taking of short lobsters.

Eleventh. Preparation of an exhibit at the Pan-American Exposition.

Your commission felt keenly the death of Governor Gregory. He took a genuine interest in the work of the commission, not only in his official capacity, but personally as a resident of the State and the town of Wickford, where the laboratory is located.

Five years ago your commission undertook a systematic survey of the marine animals of Narragansett Bay, for the purpose of gaining an accurate first-hand acquaintance with them and the conditions in which they live. It was believed that this procedure would in time prove to be of direct benefit to the fishing industries, which are of great importance in this State. In this work we have had the support of your honorable body, in generous appropriations which have been spent carefully, and for which returns have been made each year in the form of investigations of the problems which seemed most to need solution. We have enjoyed, also, the hearty coöperation of the residents of the State, especially of the fishermen, and this has added much to the efficiency of our efforts.

The plan of the scientific work was laid out by Dr. H. C. Bumpus, who directed it for four years. His resignation from the commission, made necessary by his removal to New York, we cordially regret.

The first laboratory of your commission was a small house-boat, located in the Kickemuit river. In 1899 an old scow was purchased, refitted, and moored in Mill Cove, at Wickford. Those two crude structures served their purpose well and proved beyond a doubt that the floating laboratory—though a novel scheme—was superior in many respects to a more elaborate plant on shore. They were, however, inadequate to the increasing demands of the work; indeed, it was quite impossible to keep them afloat. The second house-boat—the scow—is now on shore at Wickford, and

HOUSE-BOAT AT WICKFORD, R. I.

serves as a most valuable adjunct to the main laboratory. The house upon it has been extended, and furnishes room for sleeping-quarters, and for storing apparatus, etc.

A new structure was built and launched in 1900. This house-boat laboratory has met all expectations, and is satisfactory in every respect.

The new house-boat laboratory was built by the Providence Dry Dock Company, in April, 1900, and is a thoroughly staunch craft. A brief description of it is as follows: There are two pontoons, 52 feet long, 4 feet wide, and 4 feet deep, of three-inch hard pine, completely decked with two-inch hard pine; each pontoon has three bulk-heads and four water-tight compartments accessible by hatches. The pontoons are placed 8 feet apart and securely fastened together by cross-beams and knees at each end, and are painted all over, having copper paint below. A house 10 x 10 feet is located at each end of the boat, with floors of two-inch hard pine, and with roof, sides, doors, shelves, and closets of North Carolina pine. They are painted white outside, and finished in natural wood inside. The roof, 7 feet from the floor, is covered with canvas and painted. The well between the pontoons is open from one house to the other for a distance of 20 feet, and under the houses is accessible through hatches in the floors. The more exact measurements and proportions are given in the accompanying drawing smade to scale. In drawing number 4 the strucures under the house are shown at one end, while in the other we have a ground plan of the floor. The craft is secured at one end by two mushroom anchors, placed about thirty feet apart, from which cables are brought together into a swivel, then through the ring of the swivel is passed a galvanized-iron chain which is made fast to bits on either side of the house. By this arrangement the strain upon each anchor is mainly in one direction, and the boat is always headed into the wind without swinging as it would if the chains were attached to one bit. At the side of the house-boat booms are rigged, to which the small boats may be tied. One or more floats are also usually attached to the house-boat, in order

to furnish additional room for the hatching-cars. An awning may be spread between the roofs of the two houses on a gas-pipe frame, which can easily be removed. This laboratory serves as the head-quarters for the scientific work of the commission. Excursions are frequently made to other parts of the Bay in the small naphtha launch which was bought two years ago, and which has proved to be very serviceable and satisfactory, although it is not large enough to go with safety outside the Bay. It has been absolutely essential to much of the work in the clam experiments.

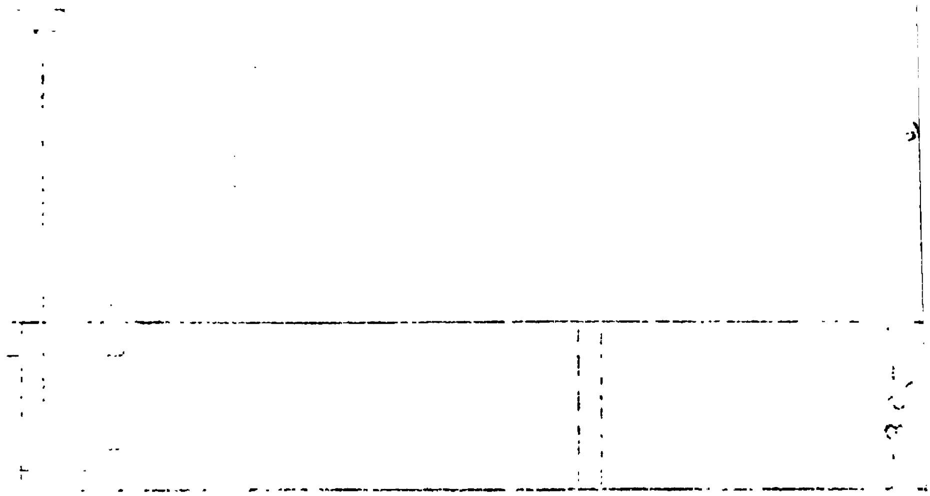
During the past season the efforts of the commission have been directed mainly to perfecting the methods of clam and lobster-culture, and have met with greater success than was expected. For the first time, lobsters have been reared from the newly-hatched fry and carried through the winter; and the invention of a practical method of rearing them through the early critical period to the fourth stage is an important step. A considerable advance has been made in the experimental propagation of clams.

Your commission believes that the State is now beginning to be benefited in a practical way by the results of the investigations on the clam and the lobster, and that further benefits will accrue. The investigation of the red water is being extended, as well as other systematic collections of data on the physical and biological conditions of the waters of the Bay.

An exhibition illustrative of the work of the commission was prepared and sent to the Pan-American Exposition, at Buffalo, and was awarded a gold medal.

An attempt has been made to enforce the law prohibiting the taking of short lobsters, and has necessitated the expenditure of a considerable sum of money in defraying the expenses of the deputies. The usual work of restocking the streams and rivers with fish has been carried on in the ordinary manner and with good effect. Taken all together, the results of the past year have been of exceptional value.

The receipts and disbursements of the commission have been as follows:



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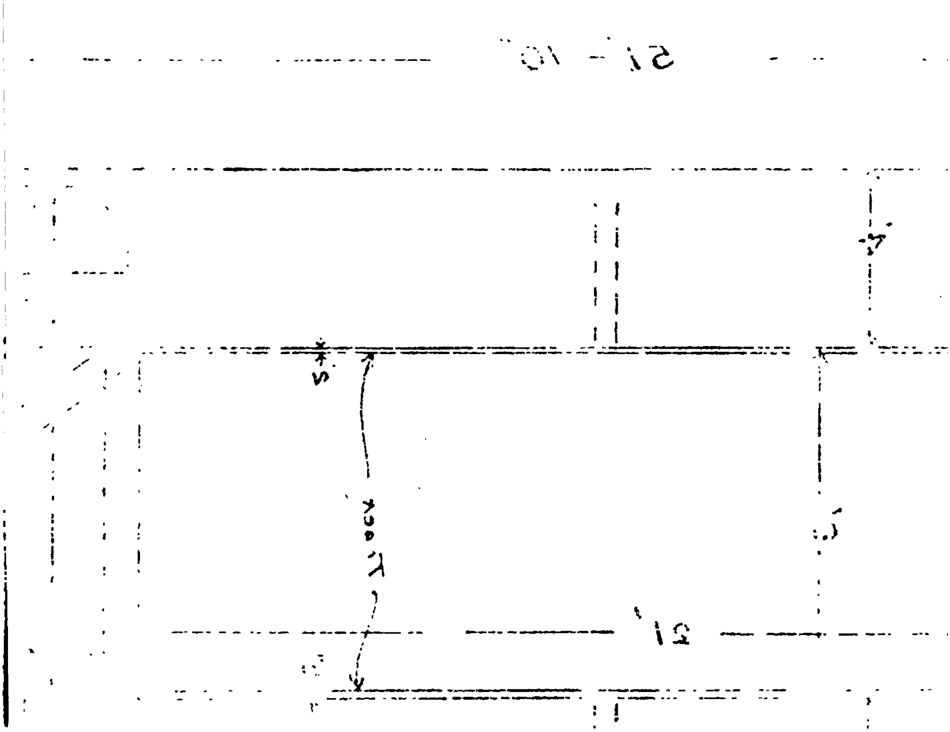

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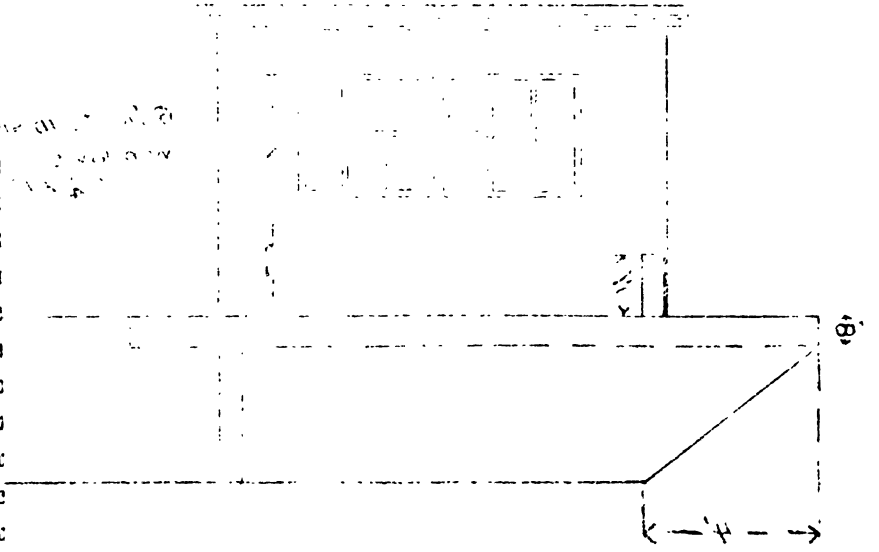
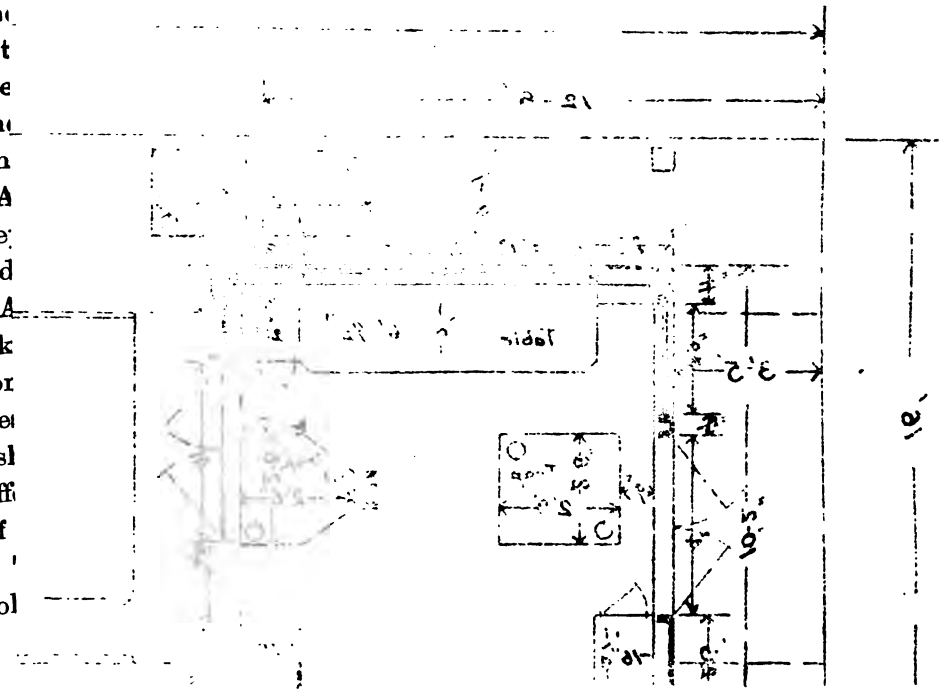




State of Rhode Island in Account with Commissioners of Inland Fisheries.

1900.		Dr.	
Dec.	31.	To balance due commissioners	$84 69
1901.			
Oct.	22.	To paid for 32,000 yearling trout, and distributing same	812 15
Dec.	31.	To expenses of laboratory on lobster, clam, flat-fish, and scallop	1,347 06
		To expenses of deputy commissioners under new lobster law	1,511 81
		To printing, stationery, and postage	96 00
		To planting shad, 2,125,000	16 50
		To expenses of commissioners	764 48
			$4,632 69

1901.		Cr.	
Jan.	9.	By cash from State Treasurer	$2 35
		" " "	19 50
		" " "	91 04
		" " "	32 00
March	13.	" " "	11 25
April	2.	" " "	16 50
		" " "	12 03
		" " "	75 00
		" " "	72 68
		" " "	100 00
		" " "	45 00
		" " "	22 52
	3.	" " "	8 60
	9.	" " "	4 00
		" " "	5 80
		" " "	57 92
May	2.	" " "	50 00
		" " "	9 00
	4.	" " "	6 20
	9.	" " "	2 00
June	4.	" " "	60 56
		" " "	66 20

1901.				
June	4.	By cash from State Treasurer		6 44
		" " "		19 25
	27.	" " "		16 54
July	2.	" " "		73 57
		" " "		70 45
	9.	" " "		2 00
		" " "		41 00
	12.	" " "		5 80
		" " "		45 15
	31.	" " "		107 00
		" " "		109 65
		" " "		170 58
		" " "		19 00
Aug.	1.	" " "		5 25
	6.	" " "		81 25
		" " "		81 95
	9.	" " "		1 00
		" " "		61 00
		" " "		18 00
		" " "		45 00
		" " "		112 50
		" " "		12 92
		" " "		40 00
		" " "		110 00
	21.	" " "		129 85
Sept.	3.	" " "		70 50
		" " "		76 55
		" " "		86 85
		" " "		26 65
	4.	" " "		18 00
		" " "		52 25
	11.	" " "		50 00
		" " "		374 70
Oct.	11.	" " "		2 00
		" " "		71 60
		" " "		77 35
		" " "		60 30
		" " "		3 50
		" " "		23 50

1901.			
Oct.	21.	By cash from State Treasurer	800 00
Nov.	7.	" " "	49 00
		" " "	76 55
		" " "	65 00
	12.	" " "	40 00
	18.	" " "	127 91
Dec.	6.	" " "	74 05
		" " "	52 50
		" " "	67 35
	12.	" " "	15 00
		" " "	77 81
	31.	By balance due commissioners	37 07
Total			$4,632 69

I. The Stocking of our Ponds and Streams with Suitable Fresh-water Fish, Through the Distribution of Eggs and Fry.

Trout.

The commission has purchased, during the past year, and planted in the several streams of the State, 32,000 yearling trout. Good catches of trout have frequently been reported by the fishermen.

Shad.

The commission has received from the United States Fish Commission, through the courtesy of the Hon. George M. Bowers, the following shipments of shad fry: June 4, 1901, 2,125,000, which were distributed as follows: 350,000 in the Pawtuxet river, 700,000 in Runnins river, and 1,075,000 in Palmer river at the shad factory. The trap fishermen made good catches of shad in the early parts of the spring, both in Palmer river and in Runnins river. Several complaints were made to the commissioners that the length of the leaders of some of these traps was too great, and the owners were promptly notified and shortened the leaders.

Large-Mouth Black Bass.

The restocking of ponds and streams with this species has been attended with gratifying success. In all waters in which they have been placed the results have amply repaid the small outlay.

Pawcatuck river, from Niantic dam to tide-water, now affords good fishing, where formerly it produced no food-fishes of any practical value. During the past season it has been the rule rather than the exception for the mill-hand to make a catch of several of these fish after finishing his day's work.

Through the courtesy of the United States Fish Commission a consignment of three hundred yearlings, averaging five inches in length, were received in November and placed in the preserve near Wood River Junction, for the future use of the Rhode Island commission in restocking other waters.

The commission received, on November 13, 1901, from the United States Fish Commission, another consignment of two hundred and fifty. These were planted in Quidnick reservoir, and in Skinflint and Hospital ponds. The commissioners believe that the large-mouth and small-mouth black bass are steadily growing in favor as an edible fish as well as a game fish, and expect soon to be able from their own resources to plant both kinds in the waters of the State, not already stocked, which are suited to them.

Alewives.

Mr. G. A. Griffin, of Wakefield, reports that for fifty years the alewife fishery has been carried on in Rhode Island. During the last thirty years, the importance of the industry has been considerable—not because of the greater abundance of fish, but because of the greater efforts in catching and preserving them. During the present year, 3,189 barrels have been prepared for export, and perhaps a hundred barrels have been sold to the local markets. A great part of these are taken in Point Judith pond, although from three to five hundred barrels came from Narrow river. There are at present about six different parties in Rhode Island

who pack these fish for export. Most of the product is bought by New York wholesale dealers and shipped to the West Indies. The average price per barrel during the last year was $3.75—somewhat smaller than that of the year before.

The method of preparation of the alewives is briefly as follows: They are put into the strongest possible brine for twenty-four to forty-eight hours. They are then turned over and stirred and left two days, then handled again in the same way and left for two days longer. At the end of a week they are ready to be packed in barrels. They are packed as closely as possible—about two hundred pounds to a barrel—and a large amount of salt placed on the top. As the barrels must be specially made, and as nearly two bushels of salt are used for each barrel of fish, the profit in this fishing is smaller than might be at first expected.

II. A Collection of Definite Data Respecting the Times of Arrival and Departure of Various Food-Fishes, and Statistics of Exportation.

The following table gives the amounts of the monthly exports of fish, lobsters, and sword-fish shipped from Newport in the year 1901 by regular transportation lines:

	Fish, Barrels.	Lobster, Barrels.	No. of Sword-fish.
January	598	236	..
February	289	243	..
March	31	340	..
April	149	296	..
May	16,776	444	1
June	19,034	499	20
July	4,815	792	..
August	4,471	922	..
September	1,077	213	..
October	2,024	184	..
November	575	106	..
December	661	118	..
Total	50,500	4,393	21

The following is a table showing the shipment of fish, lobsters, and sword-fish by the principal transportation lines from Newport during the last eleven years:

	Fish, Barrels.	Lobster, Barrels.	No. of Sword-fish.
1891	18,032	2,204	...
1892	26,832	2,123	...
1893	24,452	1,399	...
1894	17,861	2,392	...
1895	24,622	2,119	...
1896	33,064	2,115	143
1897	25,098	2,039	45
1898	34,065	1,163	74
1899	34,917	4,143	162
1900	38,184	4,793	166
1901	50,500	4,393	21
Total	327,627	28,823	611

Bay Fishing.

The early fishing for tautog was exceptionally good this year. A few small "tinker" mackerel were taken in the upper part of the Bay, above Gaspee Point, which is very unusual.

Menhaden.

The menhaden have been extremely numerous in Narragansett Bay during the summer, great numbers of them having come into the upper parts of the Bay and died for one reason or another.

In Wickford there were many schools throughout the greater part of the summer, and sometimes were so numerous about the house-boat that they managed to flop over into the cars which contained the young lobster fry.

Blue Fish.

During the early part of the season, the blue fish were observed in enormous numbers in the Bay, and on one or two occasions the

schools extended over immense areas, as observed by one of the fishermen in crossing from Wickford to Conanicut Point.

III. The Location of Fish-Traps Within the Waters of Narragansett Bay, and the Collection of Statistical Data Bearing upon their Ownership.

With the publication of the report for 1898, the State first came into possession of definite data respecting the location and ownership of the numerous fish-traps within the Bay and immediately outside, between Sakonnet and Point Judith. In the reports for 1899 and 1900, revised lists of these traps and their owners were published, and during the past season traps have again been located, as will be seen in the following chart. A list of the principal owners of the fish-traps is here given, together with the localities in which the traps are set, as follows:

Inside Traps.

Almy, Frank K. (000)*.....Sakonnet river.
Brownell, John.....West shore, Sakonnet river.
Brown, Edward.....Rumstick Point.
Carpenter Bros.....S. Ferry wharf, Saunderstown.
Carpenter, Geo.....Beaver Head.
Calvert, Geo.....Spouting Rock.
Corey, Ed. (000).....Lower west shore, Sakonnet river.
Corey, Ed. (000).....Lower west shore, Sakonnet river.
Corey, George and Martin (00).....East shore, Sakonnet river.
Corey, George and Martin (00)...Lower east shore, Sakonnet river.
Corey and Seabury.....Upper west shore, Sakonnet river.
Cottrell, S.....N. Popasquash Point.
Cottrell, S.....N. Popasquash Point.
Cottrell, S.....N. Popasquash Point.
Cottrell, S.....W. Mount Hope.

* The three ciphers signify triple traps, and two ciphers double traps.

Cottrell, S.....S. Mount Hope.
Cottrell, Wm.....Tiverton.
Cottrell, Wm. (00).....Tiverton.
Dennis, Wm.....Upper east shore, Sakonnet river.
Doane, S. P.....Rumstick.
Easterbrooks, Comer (00).....Price's Neck.
Fish, Clinton.....Tiverton.
Fish, Clinton (0).....Tiverton.
Gladding, A. B.....Castle Hill, South.
Gladding, A. B.....Coddington Cove.
Gray, Chas.....East shore, Sakonnet river.
Gray, George E.....West shore, Sakonnet river.
Gray, George E. (000).....West shore, Sakonnet river.
Gray, George E.....West shore, Sakonnet river.
Gray, George E. (000).....Prudence.
Griffin & Taylor.....Watson's Pier.
Harvey, Charles.....West shore.
Helger, Henry (000).....West shore, Sakonnet river.
Hicks, O. G.....Castle Hill, South.
James, Arnold.....N. Coddington's Cove.
James, Arnold.....Conanicut, Potter's Cove.
Kaye & Brayton.....Prudence.
Kaye & Brayton.....Prudence.
Kaye & Brayton.....Prudence.
King, Chas.....East shore, Sakonnet river.
Lake, Isaac.....Conanicut.
Lake, Isaac.....Conanicut.
Lake, Isaac.....Quonset Point.
Lawton, Ed.....Mackerel Cove.
Lawton, Wm.....Mackerel Cove.
Lawton, Ed.....Castle Hill, South.
Lawton, J. M.....Brenton's Cove.
Lewis Bros.....Plum Beach.
Lewis Bros.....Plum Beach.
Lewis Bros.....Wild Goose Point.

Lewis Bros.....Sauga Point.
Lewis Bros.....Dutch Island Harbor.
Lewis Bros.....Conanicut.
Lewis Bros.....Conanicut.
Lewis Bros.....Conanicut.
Lewis, Will (000).....West shore, Sakonnet river.
Lewis, Will.....Fogland Point.
Locke, Moses.....Apponaug.
Madison, Peter.....Apponaug.
Manchester & Grinnell.....West shore, Sakonnet river.
Manchester, Daniel.....Quonset Point.
Manchester & Grinnell.....Sakonnet river.
Matteson, C.....Fox Hill.
Mitchell, G. D.....Dutch Island Harbor.
Negus Brothers.....Mount Hope.
Negus Brothers.....Mount Hope.
Northup, Al.....Beaver Tail.
Payne, ——.....Hope.
Rice, Herbert H.....Warwick.
Rose, Chas. (00).....East shore, Sakonnet river.
Rose, Geo.....Spar Island.
Rose, Geo.....Mount Hope, east.
Rose, Geo.....West shore, Sakonnet river.
Rose, Ed. and Sam. (000).....East shore, Sakonnet river.
Rose, Ed. and Sam.....East shore, Sakonnet river.
Simons, John.....Upper Sakonnet river.
Spink, J. W.....Dutch Island Harbor.
Spink, J. W.....Fox Hill, north.
Spink, J. W.....Prudence.
Sisson, ——.....Chippanogsett.
Sisson, ——.....Chippanogsett.
Taber, ——.....Tiverton.
Tourgee, P.....Beaver Tail.
Tourgee, P.....Beaver Head.
Tourgee, ——.....Bush Neck Cove.

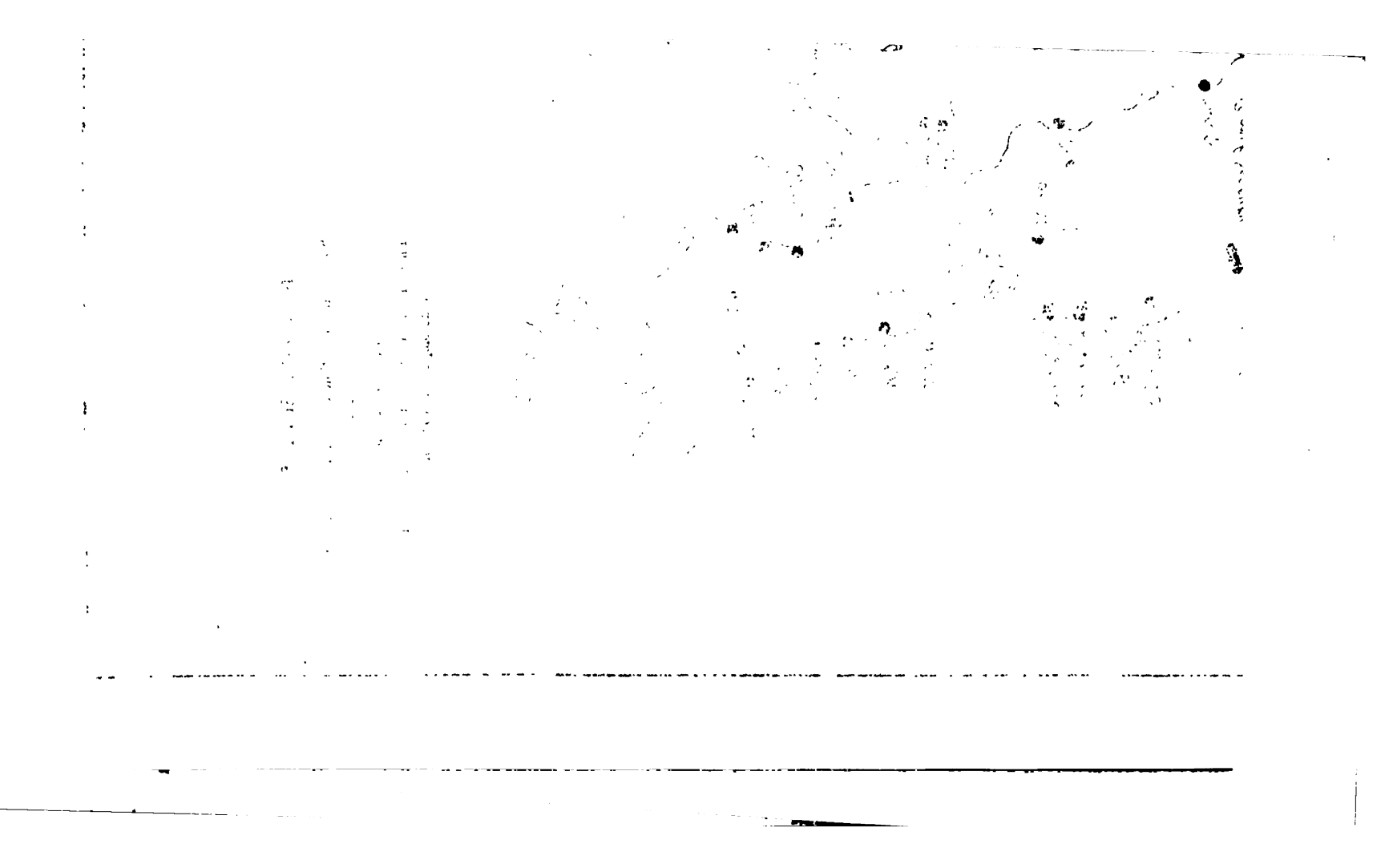
Wilcox, Ralph.....East shore, Sakonnet river.
Wilcox, Ralph.....East shore, Sakonnet river.
Wilcox, Ralph.....East shore, Sakonnet river.
Wilson, Al.....Potowomut Rocks.
Wilson, Al. (00).....Prudence.
Wilson, Al.....Pojac.

SEA TRAPS.

Brightman, W. J.....Off Seal Rock.
Brightman, W. J.....Off Coggeshall's Ledge.
Brownell, John.....Seal Rock, south.
Brownell, John.....South Cormorant Rock.
Church, D. T. (00).....South Sakonnet Light.
Church, J. B.....Off Seal Rock.
Church, J. B.....Off Coggeshall's Ledge.
Church, J. B.....South Cormorant Rock.
Church, Jos.....Off Cormorant Rock.
Church, J. B.....West Sakonnet Light.
Cook, Chas. (00).....North Sakonnet Light.
Gray, Benj.....Sakonnet Light.
Gray, Chas.....North Sakonnet Point.
Rose, Geo.....Sakonnet Point.
Rose, Wm.....Off Coggeshall's Ledge.
Rose, Wm. R.....Off Seal Rock.
Thompson, Noah.....Off Seal Rock.
Wait, Benj.....North Sakonnet Point.
Wilcox, Frank.....Off Sakonnet.
Wilcox, Frank.....Sakonnet Point.
Wilcox, Ralph.....South Cormorant Rock.
Wilcox, Grinnell & Co.....Sakonnet Point.

IV. EXPERIMENTS RESULTING IN A NEW METHOD OF HATCHING FLAT-FISH EGGS.

The success which attended experiments in keeping star-fish, clams, lobsters, and various other marine animals in cars at the



house-boat suggested that it might be possible to hatch the eggs of the flat-fish without the use of such apparatus as is usually found in the hatching-stations; and accordingly a few preliminary experiments were made during the latter part of March, at Wickford. The flat-fish were stripped in the usual way, and the eggs thus obtained were put into shallow cars, the bottoms of which were covered with fine-mesh wire screen in some instances, and in others with the scrim which was used in hatching lobsters. These cars simply floated on the surface of the water; and the eggs, having been fertilized, were left in the cars without further care. The results showed that this extremely simple method was very effective, for the flat-fish were hatched in large numbers, and apparently the only eggs which went bad were those which were allowed to remain sticking together in masses of considerable size.

The invention of so simple a method of hatching flat-fish eggs makes it possible to establish stations at almost any place where the water is comparatively quiet; and it may be possible to devise similar apparatus for hatching the eggs of other fishes.

V. Further Investigation of the Red-Water Plague.

The annual recurrence of the so-called "red water" in Narragansett Bay, and the wholesale destruction of fish, shrimp, crabs, and other animals which seems to be associated with its occurence, has led us to make a special effort to ascertain the life-history of the Peridinium, the animal which has been shown to be responsible for the red water, and to ascertain, if possible, how the disastrous effects are brought about. Accordingly, this whole problem has been assigned to Mr. E. W. Barnes, who has had considerable training in this particular line of work, and already valuable data have been brought together. It seems best, however, not to publish more than a report of the progress at this time, as the investigation will require one or more years and will appear in a subsequent report.

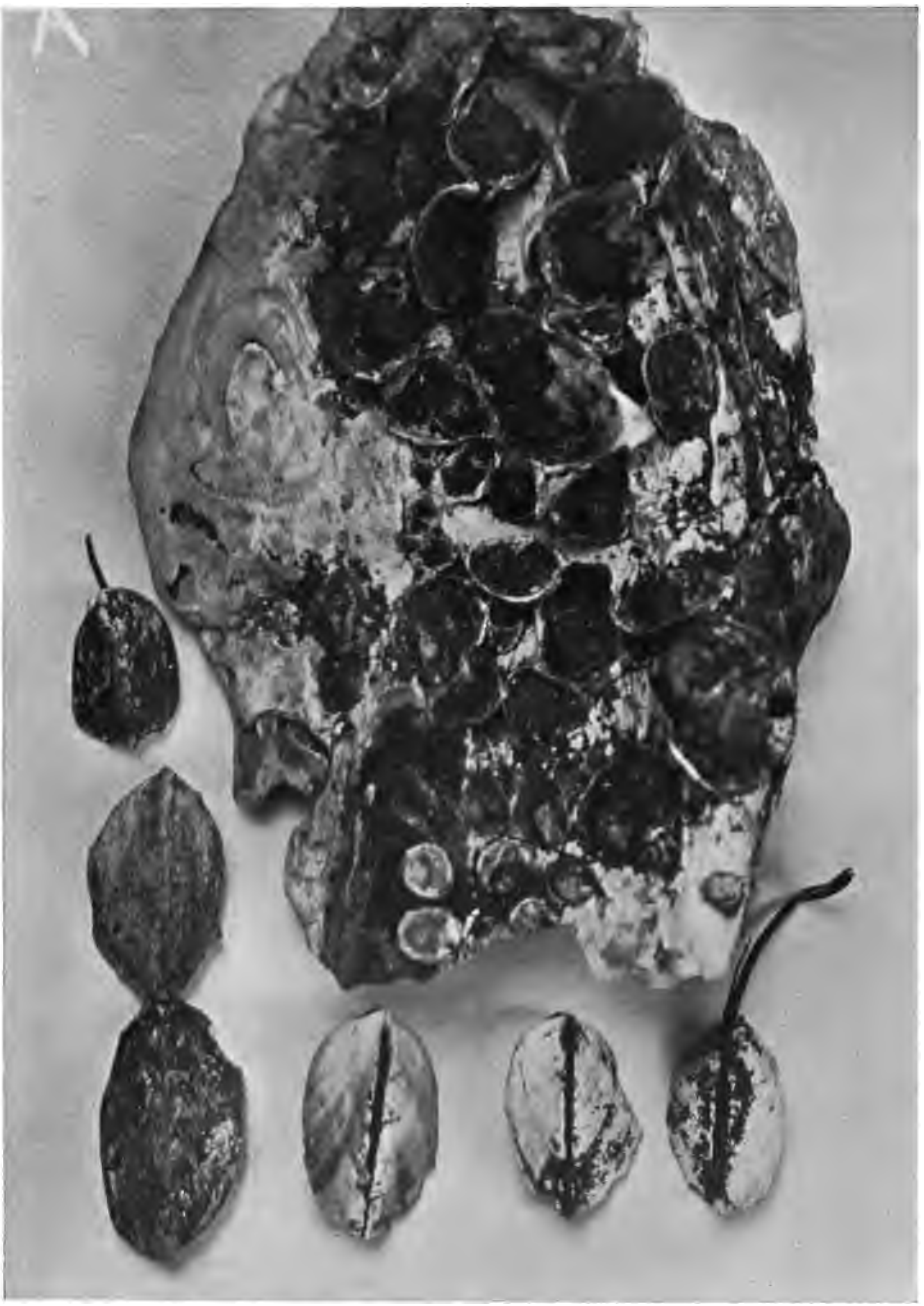
VI. The Continued Examination of the Physical and Biological Conditions of the Waters of the Bay, begun in 1898.

During the past season a daily record was kept of the density and temperature of the water; a daily record of the microscopic plants and animals taken at the surface of the water with a fine tow-net; and also miscellaneous notes regarding other physical and biological conditions—all of which are preserved for future reference.

Mr. George A. Griffin, of Wakefield, has informed the commission of some interesting facts concerning the results to the oyster and clam industry which followed the opening of the breach into Point Judith pond, early in the summer 1901. Formerly, before the breach was closed, oysters and clams were abundant in this pond—the clams growing to remarkable size, while the oysters were stunted. When the breach remained closed for a considerable time, the water became so fresh that all of the lobsters and clams were killed; and this was the condition of things in the early part of 1901. During the spring, Mr. Griffin planted a number of oysters and clams in the pond after the breach had been opened, in the hope that the canal which was to be built during the summer would keep the breach permanently open. The canal has been dug, and oysters and clams have set abundantly throughout the whole pond. A sample of the oysters is shown in the accompanying figure.

VII. A Continuance of the Survey of the Shores of the Bay, Made for the Purpose of Determining Those Portions Which are Most Productive of Young Seed-Clams.

Many miles of the shore were examined for seed-clams, and, as will be seen in the next chapter, very many were very thick in certain localities. The data collected from year to year in this way will be valuable in the future work of the commission. One



This figure is reproduced from a life-size photograph, and represents a sample of the newly-set oysters taken from Point Judith pond by Mr. George A. Griffin. The small specimens are seen to be very thickly scattered over the surface of the large oyster shell, and the larger specimens below and to the left represent oysters which have set on the widgeon grass. The under surface of these oysters bears a deep groove made by the growing of the shell around the spear of grass.

general conclusion seems to be warranted, namely, that the especially productive areas are not the same from year to year.

VIII. A Continued Investigation of the Life-History of the Clam. Methods of Artificial Propagation and Cultivation.

This investigation has been continued, with the laboratory at Wickford as headquarters, and experiments have been conducted in other parts of the Bay. The work this year has been based upon the observations and experiments made during the two previous years upon the natural history of this shell-fish. Your honorable body granted permission to this commission to have for experiment three acres of land between high and low tide, on which to conduct experiments on a larger scale than was heretofore warranted by our knowledge of the methods of clam-culture; and an account of the same will appear in the following pages. In this work the commission had the co-operation of the United States Fish Commission, and has been the recipient of many courtesies from gentlemen owning land bordering the shores.

In the following paper will be found the results of the investigations of the past season.

OBSERVATIONS ON THE SOFT-SHELL CLAM.

(THIRD PAPER.)

A. D. MEAD.

In the spring of 1898, the Rhode Island Commission of Inland Fisheries began its investigation of the natural history of the soft-shell clam (*Mya arenaria*). It was the purpose of this investigation to ascertain by systematic observation and continued experiments the life-history and habits of this shell-fish, on the principle that the facts thus ascertained would furnish the most secure foundation for a practical method of artificial clam-culture, or would discover a way of replenishing the shores, without resorting to the expedient of leasing to private parties.

An account of these researches is given in detail in the reports of 1898, 1899, and 1900; and during the season of 1901 the effort has been to apply the information thus gained. Of the many problems which presented themselves to be solved by systematic investigation were the following:

What is the breeding season?

How, when, and where are the eggs laid; and what are the habits of the young fry before they set and begin to burrow?

What is the rate of growth of the clams after they have set?

At what age do they breed?

What are the natural enemies of the clam?

What is the food of the clam?

Without repeating the account of the investigations of these problems, as they are recorded in the previous reports, we may

very briefly summarize some of the results which have been found of special service because of their practical application.

Summary of Natural History.

The breeding season was found to be, for the most part, in June, though it begins in May and ends in July. Clams spawn to some extent also in other months, but in comparatively small numbers. In the early spring (April) a meagre set is sometimes found, which, from the uniform size of the specimens, seems to represent a definite breeding season, probably in the late autumn. This set is so sparse that it can hardly be considered to be of any economic importance. (Report for 1899, page 23; report for 1900, pages 22 and 23.)

The sexes of the clam are separate. The eggs are of microscopic size and are laid in inconceivably great numbers wherever adult clams abound, being extruded without any means of protection into the sea-water, where they are fertilized. The young larvæ which develop from these eggs are swimming animals of microscopic size also, and are carried by the tides and scattered in every direction until, after a period of several days (the exact duration is not known), they strike upon some object like sea-weed, stones, or the ground itself, and become attached by an apparatus exactly comparable to the anchor-threads of the common mussel. But, although the spat is everywhere present in the water, the density of the set along the shore is very unequally distributed; so that in one area the little clams may be found in great abundance, while in other areas, not far off, very few are to be found. It is also true that these areas which are most favorable for catching the spat are often not favorable for the future growth of the clams. The significance of these peculiarities of the young clam for the future of the clam industry cannot be overestimated. (Report for 1899, pages 23 to 27.)

The problem of the rate of growth of the clams after they have set has received a large amount of attention, on account of its

obvious practical value, and the results are given, illustrated by numerous photographs, in the reports for 1899 and 1900. The rate of growth varies greatly according to the locality, and the variation can be referred back still further to two general conditions: 1st, the position of the individual clams as regards comfortable surroundings; and 2nd, of more importance, the position in relation to the abundance of food-supply. In certain localities, and at certain depths of water, the average food-supply is greater than at others. Moreover, the longer the water covers the clams, the longer time they can feed; for they derive all of their food from the water, and can take it only when they are submerged. Other conditions being the same, clams grow more slowly near the high-water mark. The Japanese take advantage of this fact, as Mr. Nishikawa, of the Imperial Fisheries Bureau, of Japan, informs me in the following extract from a letter which I take the liberty to quote: "In the Gulf of Kojima there is a contrivance to retain the shells in their fixed size, for the purpose of export to China. The Chinese use only the moderate sized *Arca sp.*, about one inch in length. The culturists plant the mollusks densely, at a distance from the low-water mark, in beds which are submerged only a short portion of the day. By this method the shells can be retained at the two-years-old size for six or seven years. I am very glad to tell you that this contrivance is one which accords with the conclusions which you have come to from your own experiments." In some of our experiments, individual clams grew from one-half inch to three inches between the middle of July of one year and the middle of September of the year following. These three-inch clams were about one year and four months old, as they were spawned in June. Without taking into account the extreme variation, the one-year-old specimens vary between three-quarters of an inch and two inches in length.

Contrary to the opinion ordinarily held, the clams reach sexual maturity and breed during the first year of their life.

In regard to the natural enemies of the clam, it is doubtless impossible to enumerate them all. Of the eggs laid, probably great

numbers perish without being fertilized. Of the numerous number which reach the swimming stage of development, it is certain that only relatively few are successful in burrowing. During these early stages, not only are they preyed upon by innumerable small predaceous animals, but the chances of perishing by falling upon unfavorable ground where they are smothered by the silt, or where they cannot burrow on account of the rocks, are equal, if not greater than their chances of falling upon good ground. When they begin to burrow they are subject to the attacks of the crabs, eels, star-fish, and probably many other enemies; and those which attain a somewhat greater age are continually being dug out of their burrows by man, and thus exposed to the attacks of fishes and all other enemies, even if they are not actually carried away by the clam-diggers. There is some evidence that in certain parts of the Bay the red water has worked havoc among the clams, as was mentioned in the last report. It is probable, however, that the excessive and indiscriminate digging is largely responsible for the decrease in the clam product of the Bay.

The clam gets its food-supply from the sea-water, which is drawn in through the incurrent openings of the snout or siphon. It consists of microscopic organisms of various sorts, a large portion being diatoms. The abundance of this food varies in different localities, and in the different depths of water, and at the various times of the year. The clam feeds continuously, if it is comfortably situated, when covered with water.

Summary of Previous Experiments.

The observations of the natural history of the clam, which have been summarized briefly above, suggested numerous problems relating to clam propagation, which required experimental tests.

Methods of Collecting Clam-Spat.—In oyster-culture, one great feature is a successful collection of spat; and the value of the oyster industry depends in not a small degree upon the economy and certainty with which such spat can be collected and trans-

planted. And it is obvious that this is also a very important feature in any scheme of clam-culture. The methods which are successfully used with oysters cannot be applied in the case of the clams, on account of their very different habits, so that new methods must be developed. The study of the egg-laying habits and the peculiar behavior of the young clams have suggested numerous schemes for the development of such a method.

First, a number of experiments were made for the purpose of ascertaining whether it would be feasible to obtain the spat by artificial fertilization of the eggs. Although the eggs can to some extent be artificially fertilized, the outlook for this method cannot be said to be very bright.

Another promising method was suggested by the enormous numbers of the free-swimming fry, which may be found at almost any time at the surface of the water during the breeding season—for about six weeks. When these swimming larvæ were captured by means of a fine bolting-cloth net, and their behavior observed under the microscope, it was noticed that a sudden agitation of the water in which they were swimming, caused by a sharp tap on the side of the dish, caused the animals to cease swimming, close their shells, and sink to the bottom. On the basis of this and similar observations, a contrivance was constructed which it was hoped would have the same effect upon the swimming fry while they were in the sea. This device consisted of a square box without a bottom, set into the ground, with the sides projecting several inches above the ground, and with the top covered by a fine galvanized wire screen. It was hoped that the larvæ, striking against the wire screen, would close their shells and drop to the bottom of the box, and subsequently burrow in the sand. The sides of the box projecting above the general surface of the ground would tend to prevent their being swept away by the tides, and those which rose to the wire screen on the top would fall again. The first test of this device was made in the summer of 1900. At the beginning of the breeding season, this apparatus was put into use in a locality where the clam-set, as a rule, is very sparse. In August, when the clams

are usually but a quarter of an inch long, this box was examined, and from one square foot of the sand in the bottom *thirteen hundred clams* were taken. They were, of course, of small size, and the thirteen hundred measured in bulk three-quarters of a pint. These clams were carefully transplanted and, although many have been preserved as specimens for future reference and others were destroyed or lost in the handling, on August 22d of the following year we still had five hundred and thirty-two specimens from this lot. At this time they measured fourteen quarts. The average length of these was slightly over two inches—this average being computed from careful measurements of about seventy-five specimens taken at random.* It should be said that in the immediate vicinity of this clam-catcher there were almost no small clams to be found, so that undoubtedly the extraordinary find within the box demonstrated the feasibility of this method of obtaining the spat.

During the summer of 1900 several similar spat-catching apparatus were put down in various localities. Some of these were successful, but many of them failed to yield the expected number of young clams. There is very good reason to believe that the failure of these was due to neglect in one particular feature, namely, in having the sides of the box set well into the sand, for it was noticed that wherever the apparatus failed to catch the spat, the water had been allowed to run out of the box under the edge, and so to carry out the spat which had been precipitated through the screen top. In one of these apparatus, which for the most part was unsuccessful from this cause, a finger-bowl with a little sand in the bottom was placed, and in this finger-bowl over one hundred clams were caught, while around the finger-bowl in the rest of the box there were comparatively few. Besides this experiment, there were several boxes covered with screen and filled with sand, which were kept under water all the time at the house-boat, and the clams were precipitated in these boxes in

* Since this was written these specimens have been again examined and the average length was slightly over 2⅛ inches. These specimens are shown in figure 4.

enormous numbers. I believe that this device for catching the clam-spat can be developed into one of very great practical utility, the main advantage being the certainty with which the young clams can be obtained.

Another method of collecting spat, and the one which has been adopted in the experiments of the past summer, was suggested by the observations of the habits of the young clams when they first begin to burrow. It was noticed, in the summer of 1899, that the clams were set exceedingly thick in several limited localities, so that, for instance, in one square yard of the shore of Cornelius Island there were taken upwards of twelve thousand clams (Report for 1899, page 29), while in localities not far distant very few clams were found. In the following summer of 1900, new localities were discovered in which the set was extremely thick, while some of the rich localities of the year before did not yield a large crop. Again, in the summer of 1901, the localities which had produced large numbers in previous seasons were found to be comparatively barren, but still other areas were located in which the yield was most remarkable. On the east shore of Green's Island a set was discovered, on August 13th, which in extent and in the abundance of the clams surpassed any of those found in the previous seasons. And from this area there were taken at intervals, up to September 7th, and transplanted, more than five and a half millions of small clams. It is difficult to describe the abundance of the specimens adequately. The ground was almost solid with clams for a distance of some two inches below the surface in many places. In order to convey some idea of their abundance, those caught and sifted in one shovelful of sand were carefully counted, and they numbered seven thousand nine hundred and ten, making something less than a quart in quantity. The sieves which were used for the collection of the spat were about two and one-half by five inches, with sides from six to eight inches in height, and the bottom was covered with about one-quarter inch mesh galvanized iron netting. In the later experiments, however, a screen with meshes about

the size of mosquito netting was used and found to be a great improvement, inasmuch as it saved enormous numbers of very small clams which were excellent for transplanting, but which would not be caught in a sieve of larger meshes. When clams can be found in such great abundance, it is not necessary to resort to the special artificial devices for collecting the spat from the water; but we must, nevertheless, bear in mind the fact before mentioned, that these rich areas are limited in extent, and that the set in any one area is uncertain from year to year.

For the practical experiments of this summer, we depended mainly for our spat upon the area just described, at Green's Island, and more than twenty bushels of these small clams were taken from this locality and transplanted.

Transplanting. — Having obtained the young clams, by one method or another, we confront several problems: the best season for planting; the best methods for caring for the material between the time of collecting and that of planting; the best method of actually planting the clams; the selecting of localities for planting, which involves, among other questions, the one relating to the rate of growth. Here, again, the natural history has pointed out the way for preliminary experiments, and a large number of tests were made during the summers of 1900 and 1901. These experiments were recorded in tabulated form in the report for 1900, pages 27 to 44. The general results may be summarized here.

The best clams for transplanting are the small ones, such as may be obtained during July and August, having been spawned in the early summer. There are two excellent reasons for this: First, clams are more easily gathered. Not only can greater numbers be obtained, but greater quantities, with the same expenditure of labor; and second, the young specimens are capable of burrowing much more readily than the older ones. Before they are five-eighths of an inch in length they are especially desirable, from the fact that they have the power of anchoring themselves when they are sown upon the surface while preparing to burrow, and

even after they have burrowed they are kept in place by these anchor-threads so that they are not uncovered and tumbled about by the action of the water. But, even leaving this factor out of account, the smaller specimens burrow much more readily than the larger ones, and the burrowing becomes more and more sluggish as the size increases.

In regard to the best method of taking care of the clams between the time of collecting and of transplanting, the experiments show that the sooner they are planted the better, but that, if they must be kept for a considerable number of hours, it is better to keep them in the air than in the water. They should not, however, be allowed to become too dry, especially if they are very small, nor should they be packed too closely together for a long time, but should be spread out in comparatively thin layers. In one series of experiments, in which the clams were sorted into four classes according to size, the average per cent. of the clams of all classes which burrowed was 91.2, when they were planted one hour or less after taking. The per cent. was 84.9 when they were planted after being kept dry twenty-four hours; and 76.3 when kept in water twenty-four hours. The rate of burrowing is facilitated by digging up the soil, though the practice has this objection—that the clams become less firmly fixed on account of the looseness of the soil which is thus softened. They burrow about as satisfactorily in light gravel as in sand, and for very small clams the gravel beds have somewhat the advantage, because the gravel gives attachment for the byssus threads which anchor these specimens.

Experiments in Clam-Culture.—Profiting by the results summarized in the above accounts, we have devoted our efforts, during the past season, mainly to larger experiments in actual clam-culture. The General Assembly of the State passed the following act, at its January session, 1901, which permitted the commission to occupy, to the exclusion of others, land between high and low water mark to an extent not exceeding three acres, for the purpose of carrying on these experiments:

AN ACT IN AMENDMENT OF CHAPTER 174 OF THE GENERAL LAWS OF RHODE ISLAND, "OF THE INLAND FISHERIES."

[Passed March 29, 1901.]

It is enacted by the General Assembly as follows:

SECTION 1. Section 2 of chapter 174 of the General Laws is hereby amended so as to read as follows:

"SEC. 2. The commissioners of inland fisheries shall introduce, protect and cultivate fish in the inland waters of the state, and may make all needful regulations for the protection of such fish, and shall prosecute for the violation of such regulations and of the laws of the state concerning inland fisheries. (*They may in their discretion, from time to time, make experiments in planting, cultivating, propagating, and developing any and all kinds of shell-fish; and for the purpose of so doing may from time to time take, hold, and occupy, to the exclusion of all others, in one or more parcels, any portions of the shores of the public waters of the state or land within the state covered by tide-water at either high or low tide, not within any harbor line and which is not at the time of such taking under lease as a private and several oyster fishery: Provided,* that the land so held and occupied at any one time shall not exceed three acres. Said commissioners upon taking such land shall forthwith give public notice thereof by advertisement in some newspaper in the county in which said land is situated, which advertisement shall contain a description of said land: they shall also forthwith notify the commissioners of shell fisheries of such taking and shall transmit to them a description of said land, and shall also stake out or otherwise mark the bounds of said land. Said commissioners may make all needful regulations for the protection of the land so taken and of all animal life and other property within the lines thereof and shall prosecute the violations thereof.) They may co-operate with the fish commissioners of other states, and they shall make an annual report to the general assembly of their doings, with such facts and suggestions in relation to the subject for which they were appointed as they may deem proper. Said commissioners, whenever complaint is made by them or either of them for a violation of any regulation made by them as aforesaid, or for violation of any of the provisions of this chapter or of chapters 171, 172, and 173, shall not be required to enter into recognizance on such complaint or become liable for costs thereon."

SEC. 2. Section 3 of chapter 174 of the General Laws is hereby amended so as to read as follows:

"SEC. 3. The said commissioners shall cause a copy of any regulation made under the authority of the preceding section to be filed in the office of the town clerk of any town in which any waters stocked with fish, or land occupied for experiments under the authority of the preceding section and to which such regulations may apply, may be, and shall also cause a copy of such regulations to be advertised in some newspaper published in the same county."

SEC. 3. Section 4 of chapter 174 of the General Laws is hereby amended so as to read as follows:

"SEC. 4. Every person who shall violate any of the regulations made by the commissioners of inland fisheries under the authortty of the provisions of the preceding three sections, or who shall take any fish, fish-spawn, or any apparatus used in hatching or protecting fish, from any pond, lake, river, or stream stocked with or set apart by said commissioners, or by private parties for the protection and cultivation of fish with the consent of the town council of the town where such cultivation is carried on, without the consent of such commissioners or, if the cultivation of fish be carried on by a private party, without the consent of the person cultivating the same, or who shall trespass within the boundaries of any land which may be taken and occupied by said commissioners for their experiments in relation to shell-fish, authorized by section 2 of this chapter, shall be fined not exceeding three hundred dollars or be imprisoned not exceeding six months or be both fined and imprisoned, in the discretion of the court before which the offender shall be tried."

SEC. 4. This act shall take effect from and after its passage.

About two acres of shore have been occupied in accordance with this act, and have been planted with clams. In the selection of the areas for planting, we have endeavored to distribute the experiments in different parts of the Bay and to occupy small areas which differ in the character of their soil. Several of these plots border upon private land, where, through the courtesy of the residents, trespassers will have their attention called to the desirability of allowing the plots to remain unmolested. Several of the plots were further protected by fences of chicken wire, which kept out ducks, and perhaps also other enemies of the young clam, like the paddlers (blue crabs).

The clams which were planted in these sections were obtained at Green's Island, at various times between August 14th and September 5th. They were collected by shovelling the sand, in which they were densely crowded, into a sieve made for this purpose. The meshes of the sieve used at first were comparatively coarse, and allowed the small clams to escape. One quart of those caught with this screen was counted, and numbered 2,135. Later a finer sieve was substituted, and the number caught in this was about 9,700 per quart.

The clams thus collected were carried in pails or tubs to the

planting-ground and sowed broadcast. The experiments were varied by keeping the seed for different lengths of time between collecting and sowing, and by keeping them sometimes dry and sometimes in water; by sowing with varying conditions of the tide —sometimes upon the bare ground at ebb tide, and sometimes upon the water; by sowing in windy and calm weather; by digging up the soil, or leaving it unmolested; and by sowing at different times of the day, an item which may be of importance because of the greater abundance of eels and other enemies at night. It is probable that nearly every one of these factors will influence the result of these experiments.

Besides the land thus occupied and staked out, several strips were planted on the shores, which will probably be dug up by the clammers. This was done in order to test the efficiency of sowing where the digging is not interrupted.

The accompanying table gives the main facts in regard to the thirteen experiments of this kind. In experiments numbered 10, 11, 12, and 13, the plots were not staked out or in any way protected.

It will not be possible, until next summer, to find out how far the experiments are successful, but already very encouraging evidence has been forthcoming in samples taken from some of the beds late in the winter.

It is to be expected that some of the experiments will be failures so far as the product is concerned, but these may be the more useful in indicating what precautions should be taken and what errors should be corrected. There is reason to expect some degree of success in other sections, and if this proves to be the case an important step will have been taken in clam-propagation which will, perhaps, warrant still further attempts on a more extensive scale.

Number.	Location.	Area.	Amount sowed.	Aver. No. per qt.	When sowed.	Condition of Tide.	Condition of wind.	Time between digging and sowing.	How kept.	Remarks.
1	S. shore, Mill Cove	a 50 x 25 ft.	36 qts.	2,135	Aug. 14, 11 a. m.	Just turning. Low about 12.	None.	24 hours.	In water.	⅛ unplanted.
		b 50 x 25 ft.	54 qts.	2,135	Aug. 17, 5:30 p. m.	Coming in. Low about 2:30	None.	26 hours.	Dry.	Plot partly grass.
2	S. shore, Cornelius Island	a 50 x 25 ft.	36 qts.	2,135	Aug. 14, 1 p. m.	Coming in. Low about 12.	None.	24 hours.	In water.	Loamy sand.
		b 50 x 25 ft.	54 qts.	2,135	Aug. 16, 5:30 a. m.	Half in. Low about 1:40.	None.	26 hours.	In water.	Loamy sand.
3	Rumstick	150 x 50 ft.	72 qts.	9,700	Aug. 17, 3 p. m.	Coming in. Low about 2:40.	Brisk.	2 hours.	Dry.	Stony beach.
4	Fishing Cove	a 25 x 50 ft.	45 qts.	9,700	Aug. 18, 10 a. m.	High. Low about 3:30.	Light.	20 hours.	Dry.	Fine gravel.
		b 25 x 50 ft.	54 qts.	9,700	Aug. 24, 5 p. m.	Half out. Low about 7:20.	Light.	4½ hours.	Dry.	Fine gravel.
5	Kickemuit River	a 60 x 150 ft.	108 qts.	9,700	Aug. 19, 2 p. m.	Going out. Low about 4:10.	Light.	4½ hours.	Dry.	Sandy loam.
		b 60 x 150 ft.	108 qts.	9,700	Sept. 7, 9:30 a. m.	Low. Low about 8.	None.	24 hours.	Dry.	Sandy loam.
6	Smith's pasture, Mill Cove	200 x 60 ft.	153 qts.	9,700	Aug. 23, 3 p. m.	Going out. Low about 6.	Light.	4 hours.	Dry.	Marl.
7	Duck Cove	100 x 50 ft.	45 qts.	9,700	Aug. 24, 6 p. m.	Going out. Low about 7.	Light.	4 hours.	Dry.	Rocky beach.
8	South shore, Mill Cove	100 x 60 ft.	108 qts.	9,700	Aug. 26, 5:30 p. m.	High tide. Low about 10.	Light.	4 hours.	Dry.	Coarse gravel & sand.
9	Old Buttonwoods	150 x 60 ft.	99 qts.	9,700	Aug. 28, 1 p. m.	Half in. Low about 10.	Light.	3 hours.	Dry.	Shifting sand.
10	*Rabbit Island	100 x 50 ft.	54 qts.	9,700	Aug. 28, 4 p. m.	Almost in. Low about 11:40.	Light.	6 hours.	Dry.	Fine gravel and sand.
11	*N. shore, Cornelius Island	200 x 20 ft.	45 qts.	9,700	Aug. 29, 5 p. m.	High. Low about 12:30.	Light.	3 hours.	Dry.	Coarse gravel.
12	*Quonset	60 x 60 ft.	36 qts.	9,700	Sept. 5, 10 a. m.	Half in. In, 1:20.	Light.	20 hours.	Dry.	Sandy and shifting.
13	*Cold Spring	60 x 60 ft.	40 qts.	9,700	Sept. 5, 11 a. m.	Coming in. In, 1:20.	Light.	21 hours.	Dry.	Sandy gravel.
	Total	2⅛ acres.								

*Not staked. Total staked out, 1¾ acres.

1. Sample of small clams taken on August 17, at Green's Island, for planting (see page 26); natural size.

2. Sample of clams taken from Green's Island on August 28 and sowed in the plot staked out at Buttonwoods. These clams were taken from the plot on January 25; natural size.

3. Specimens taken from Green's Island on August 17 and sowed at the plot at Rumstick Point, and collected from this place on January 25; natural size.

4. Samples of clams caught in artificial spat collector in the summer of 1900, and reared under fairly favorable conditions. This picture was taken from life on January 30, 1902, and is natural size. The clams were one year and a half old. See page 25.

MR. CHARLES ALEXANDER.

Beds for preserving clams, as used by
Mr. Charles Alexander.

Through the kindness of Mr. Charles Alexander, whose residence is at the shore on Rumstick Point, I have been allowed to publish a description of some interesting experiments which are, in fact, the first attempt in clam-culture by a resident of Rhode Island.

Mr. Alexander encountered the usual difficulties in procuring clams of good quality at the desired time, and invented an ingenious method for overcoming this difficulty. A series of heavy boxes was put down alongside a pier, and their covers perforated with holes. The clams, when procured, were transplanted into these boxes, which had been filled with about eighteen inches of sand. Here they grew readily, became very fat and tender, and were always on hand when desired for baking.

This device not only allows the inventor to have clams whenever he wishes them, but the clams actually grow in size; and it is the testimony of everyone who has tried them that they are superior in quality to those dug directly from the shore. Mr. Alexander has hereby demonstrated the feasibility of a method which can and probably will be used extensively by others who have land bordering upon the shores of Narragansett Bay.

The accompanying figure is taken from a photograph loaned to this commission by the owner of these beds, and gives a good idea of their structure and situation.

IX. Experiments in Lobster-Culture.

The decrease in the abundance of lobsters on the New England coast is so evident and so significant that fishermen, dealers, and consumers have for many years felt anxious for the future of the lobster industry. The legislatures of the various States have manifested their interest by enacting prohibitory laws for the protection of the female lobster bearing eggs and the young lobsters which are not old enough to breed. The United States Fish Commission has been actively engaged in artificially hatching and distributing lobster fry, with the hope that the rate of decrease might

be lessened, using, in the case of the lobster, the same methods which have been demonstrated to be effectual in the case of certain fishes.

It is a very general opinion, however, that the present method of carrying fry out to sea and putting them overboard within a day or two after they are hatched is objectionable in this respect —that no protection is afforded the fry during the early period of their life, when they are more in need of protection than before they are hatched or after this period. Although the imperfections of this method have long been recognized, it has been pursued in the absence of any known way of keeping the young lobsters in captivity until they have passed through these early stages.

In 1898 a series of systematic experiments was begun at Wood's Hole, under the direction of Dr. H. C. Bumpus, at that time director of the scientific work of the United States Fish Commission station, and a member of your commission. In 1900 the experiments were transferred from Wood's Hole to the Wickford station of your commission, where they have been continued during the summers of 1900 and 1901. The station at Wickford has proved to be more favorable for the experiments, and the work has been facilitated by the cordial co-operation of the two commissions.

A record of the progress made at Wickford during the season of 1901 is recorded in the following pages.

HABITS AND GROWTH OF YOUNG LOBSTERS,

AND

EXPERIMENTS IN LOBSTER-CULTURE.

A. D. MEAD.

The observations and experiments recorded in the following pages are a continuation of those made in the season of 1900, an account of which was published in the last report. The work during the past two seasons has been carried on at the floating laboratory of this commission, located at Wickford, R. I., in co-operation with the United States Commission of Fish and Fisheries.

It was the original object of this investigation to become thoroughly acquainted with the habits and peculiarities of lobsters from the time of hatching to the fourth stage, and thereby to discover a means of rearing them until they reached this stage, when they can be set free with far greater chances of living than they would have if liberated immediately after they are hatched.

The results of the first year's work were described in the previous paper, under the following headings, and a brief summary of these results is necessary before we proceed with the experiments of the past summer:

1. What changes in structure occur in early development?
2. What is the duration of the first three stages?
3. What are the general habits of life in the first four stages?
4. What is the best method of supplying food?
5. What is the best means of protecting the fry in the three stages?

The young lobsters, after hatching, shed their skin three times during as many weeks, and following each moult there is a marked change in the structure as well as in the size of the animals.* Accordingly, it is convenient to designate the young immediately after hatching as belonging to the "first stage;" after they have moulted once, as belonging to the "second stage," and so on. The surest and quickest means of distinguishing the different stages is by the appendages along the under side of the abdomen (tail). In the first stage there are none; in the second stage several pairs of swimmerets are present; in the third stage appendages appear upon the end segment of the tail. The fourth stage is so different from the preceding ones that no difficulty is ever experienced in distinguishing it.

The time required to reach the fourth stage varies greatly according to the temperature of the water, and perhaps according to other conditions. At Wickford this period varied from nine to sixteen days, and became shorter as the temperature became higher. At Wood's Hole the development was very much slower, and the period was nearly twice as long as at Wickford.

A great deal of attention was given to the general habits of the fry during the first three stages, for obviously the success of the experiments depends in a large measure upon understanding them. From the time they are hatched until they reach the fourth stage they are essentially swimming animals, and are in no way adapted for living on the bottom or in contact with any solid substance. They are constantly in motion; in moments of apparent rest the motion of the swimmerets prevents them from sinking, and for the greater part of the time they are swimming around or executing absurd jerking movements by sudden strokes of the tail. Only slightly do they direct their movements toward particular objects or places, but they are carried by the current in the direction of least resistance. Their constant aimless activity tends to keep them suspended in the water and occasionally brings them into

* F. H. Herrick, "The American Lobster;" Bulletin of the United States Fish Commission for 1895; and Report of Rhode Island Fish Commission for 1900.

contact with food, but does not protect them from their enemies; indeed, as they have no sense of fear and are very conspicuous in the water, they fall prey to all sorts of fishes and shrimp, and even to their own brethren.

They swim sometimes at the surface of the water, but again show a tendency to sink to lower depths. Undoubtedly the movements of the lobster fry are affected by the light, and perhaps also by the temperature, but the nature and extent of these disturbances are yet to be learned.

From the practical point of view a great deal more depends upon the understanding of their habits and the effect of temperature and light upon them than would at first appear. Indeed, one of the most serious difficulties, if not the most serious one, in the rearing of the young is that of adapting the apparatus to the peculiarities of the swimming habit.

What has been said above applies to the first, second, and third stages of the young lobster. When the skin has been shed the third time and the lobsters have entered the fourth stage, there is immediately an almost miraculous change in their habits. In this stage they become at once adapted to life on the bottom. They tend to quit their swimming habits, except for the purpose of changing their position, capturing prey, etc. They crawl over the bottom, hide under shells and sea-weed, and, if these objects cannot be found, they even burrow in the sand. For the first time the sense of fear is evinced, and they retreat from danger; there is a purpose and direction in their activities which was not apparent in the three earlier stages.

It should not be inferred that they lose the power of swimming —this is not lost for months—but the swimming is now for the purpose of going from place to place, or for retreating from danger, not merely to keep them afloat.

The moulting, or shedding the skin, first takes place when the lobster is about three days old, is repeated twice during the first two weeks, and continues with longer and longer intervals throughout life. In the first moults, as in the succeeding ones,

the process is the same, the old skin being split across the back, between the thorax and the abdomen, and the body worked out through this opening, leaving the cast-off skin otherwise intact.

The actual process of moulting usually occupies only a few minutes, but not infrequently something goes wrong and the struggle is quite prolonged. Often the lobster dies in the process, and the period of moulting is at best a very precarious one in the life of the lobster, whether in the young stages or in the later ones.

The newly-hatched lobsters feed normally upon all sorts of minute organisms (copepods, diatoms, etc.), and will readily eat some kinds of flesh, if it is chopped into fine pieces and kept suspended in the water where the fry come in contact with it. Apparently they do not distinguish food sufficiently well to go to it from any considerable distance, but take what they come in contact with; and as they are continuously moving about in an ocean full of organisms, they must rarely want for food.

When a large number of fry are kept in an enclosure, the natural food-supply, consisting of other organisms, is of course not sufficient in quantity, and other food must be introduced. The fry decidedly prefer an animal to a vegetable diet, and in providing an animal food it is necessary to select tissues which can easily be shredded or crumbled into small pieces. Shredded fresh fish is fairly good, and is very satisfactory in the later stages. The best food so far discovered is the soft parts of clams. The bodies of the clams are cut out and chopped into fine pieces in a chopping-tray and then thrown into the water.

There is one habit of the fry which makes the question of ample food-supply especially important—their atrocious cannibalism. The only way to prevent them from destroying one another is to give them an abundance of food.

There are two main difficulties in the way of providing a suitable enclosure for the fry which will allow them sufficient freedom, and which will at the same time confine them and protect them from

enemies. The fact that the young fry swim aimlessly about and are carried hither and thither by the currents constitutes the first difficulty, for when they are placed in an enclosure provided with a screen which will allow a free circulation of water from the outside, but shuts out the enemies, the fry are carried against the screen and die. The second difficulty is quite as serious, and is due to the fact that at certain times the fry have a tendency to leave the surface and sink to the lower depths. This tendency results in tremendous mortality, for the fry settle into the pockets at the lowest point and smother, or become foul with the sediment and unused food. A large number of experiments were made to discover a means of obviating these difficulties, and gradually, towards the end of the first season, we came to the conclusion that the secret of success in rearing the young lobsters was to keep the water in continuous motion. This accomplishes two things: it prevents the fry from settling into pockets where they smother or devour one another, and it keeps food in suspension so that the fry can obtain it.

To prove the correctness of this conclusion with the material and apparatus at hand, it was decided to experiment with the lobsters which were at that time in small bags. Accordingly, the force at the laboratory was divided into watches, and the water in the bags was thenceforth stirred with an oar continuously, night and day, for a week. The result was ample proof that the conclusion was correct.

Experiments in 1901.

Stirring-Apparatus.—The evident efficiency of the crude method of stirring in maintaining the life of the young fry naturally suggested that during the next season a mechanical contrivance should be arranged to do the work. This suggestion was carried into effect, and the results thereby attained during the past summer of 1901 have fulfilled expectations. They have demonstrated adequately the feasibility of protecting lobster fry through the extremely critical period of their early life.

The description of the apparatus used is briefly as follows:

A series of bags made of scrim was sunk into the water and held securely in place. In each bag, near the bottom, was placed a two-bladed rotating fan resembling that commonly in use over restaurant tables. These fans or propellers were connected with vertical shafts, which in turn were geared up to a gasoline engine. When the machinery was set in motion, the rotation of the fans created a continuous current of water, directed upward from the bottom of the bags. The force of the current could be controlled readily by various simple means, such as altering the angle of the blades.

The credit of planning and constructing the apparatus in detail belongs to Mr. George H. Sherwood, who has submitted the following description:

"The apparatus may be described as consisting of two parts: A, the car or bag (with its supporting framework) used for holding the fry; B, the mechanism (propeller, belts, shafting, etc.) for stirring the water.

"*A. The Car or Bag.*

"The requirements of the car or bag were:

"1. That it should allow for abundant circulation of water from the outside.

"2. It should have as few corners and pockets as possible.

"3. It should be fastened so that it could be readily changed and cleaned.

"4. It should be rigid enough to keep its walls from the propeller or fan.

"Galvanized wire netting was first suggested as the most suitable material for the car. This was soon abandoned, because it is so liable to breakage, and because it was feared that the current of water might carry the young lobsters against the rigid metal and fatally injure them. The scrim, such as was used for the experiments of last year, was considered more practicable. It would permit free circulation, was comparatively inexpensive, and could easily be cleaned. The only difficulty connected with its use was keeping the cloth free from the propeller blades.

"*Size and Shape of Bag.*—From this material was made a cylindrical bag a little more than three feet in diameter and forty inches deep—the

latter being the width of the goods as it comes from the factory. By making the sack of this size, it was necessary to have only two seams—one up the side, the other around the bottom of the bag. This did away with the pockets and corners which were so troublesome in the square bags last year. Along the bottom seam, on the outside of the bag, was sewed a piece of drilling four inches wide. This drilling was turned over a wooden hoop (child's rolling hoop), which was a little larger in diameter than the bag. The hoop kept the bottom taut, while it also furnished a strong attachment for the ropes necessary to hold the bag in place. In a like manner another hoop kept the mouth of the bag open.

"*The Support of the Bag.*—On the inside wall of each pontoon, and six inches above the water, there is a cleat which runs lengthwise. Every four feet of these cleats a 2 x 6 plank was laid across the well and fastened securely. To the under side of each plank were nailed three posts four feet long—one at each end and one in the middle (see diagram). To make the frame still stronger, the submerged free ends of the posts hanging from consecutive planks were joined together by scantling pieces, Brass screw-eyes were screwed into the bottom of each post.

"The bag was held in the frame just as the bowl or pocket of a fish-pound is secured. The top hoop of the bag was fastened with strings to the planks above (see diagram). The bottom was drawn down and the side of the bag stretched by means of 'down hauls' or ropes which rove through the screw-eyes in the posts. In this manner the bag was held so securely that there was little danger of the wind or tide carrying the cloth into the fan which was suspended in it. At the same time, it was a very simple matter to remove it whenever desired.

"*B. The Mechanism (fan, belts, shaft, etc.) for Stirring the Water.*

"To keep the fry from settling to the bottom of the bag, a simple two-bladed fan, similar to those so often seen in restaurants for circulating air, was suspended in the bag and revolved slowly. The blades (*F*) of the fan (see diagram) were 14m. x 5m., made of cypress, and screwed firmly to a piece of maple (*G*), one end of which fitted snugly into the ⅜-inch Tee (*H*). The blades were then set on angles and opposite to each other. The shaft of the fan was made of two pieces of galvanized gas-pipe, each three feet long, and of different sizes. One end of the lower half (⅜-inch pipe) was screwed into the Tee, and the other was joined to the upper pipe (¾-inch pipe) by a reducing coupling. The whole was then suspended in the bag by means of some 2 x 3 pieces, as shown in the diagram—the reducing

coupling serving as the bearing for the shaft. To make the fan turn easier, an iron washer was sunk into the frame, and the coupling revolved in this. When the fan was in position, the blades were about six inches from the bottom and about the same distance from the side of the bag. An 8-inch galvanized sheave (*L*, diagram) was put on the upper end of the shaft and fastened with a set-screw. A belt from the main power shaft on one of the pontoons to this wheel transmitted the power for revolving the fan. The speed needed to be sufficient to lift all the fry and the excess food from the bottom of the net, but not great enough to hurl the young lobsters against its sides. It was found that the strength of the current could easily be controlled by changing the angle of the blades.

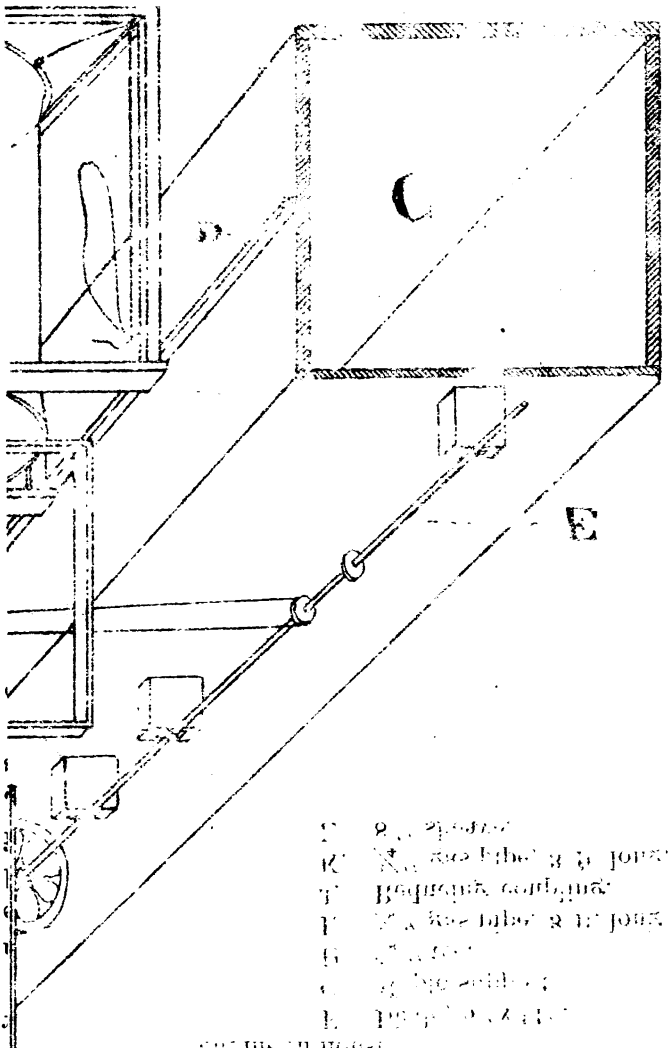
"The power for rotating the fans was supplied by a Fairbanks and Morse gasoline engine of 2½ H. P., which was placed in one of the houses of the house-boat and connected by a belt with a large driving-wheel on the main power-shaft (see diagram). This shaft was set up on the deck of one pontoon and extended the length of the well. At intervals on the shaft, corresponding to the positions of the fans, small 3½-inch wheels were fastened with set-screws. Each of these wheels was connected with the driving-wheel of the fan by a rope belt (see diagram).

"The most troublesome part of the mechanism was the belting. All the machinery, excepting the engine, was exposed to the weather. No belting was found that would stand the weather and not stretch and shrink, but finally a loose-laid inch rope, called "Russia purse-line," was used, as this seemed to be less easily affected by dampness than any other. The annoyance caused by the slacking and shrinking of the belts was lessened in two ways. A belt could be lengthened or shortened several inches by moving the sheave up or down on the shaft of the fan. When this was not sufficient, the belts were run over spools, which were fastened to the supporting posts and which acted as third pulleys.

"The fans revolved at the rate of 15–20 turns per minute, and produced a current which took all the material from the bottom, and still allowed a comparatively uniform distribution of fry in the upper part of the bag. Undoubtedly a smaller engine would have turned the twelve fans without difficulty.

"From the foregoing, it is readily seen that the apparatus is simple in construction, and that it would be neither difficult nor expensive to adapt or construct similar apparatus for economic lobster-culture."

10. From a photograph of the apparatus used in rearing the lobster fry at the house-boat at Wickford. The tops of the bags or cars may be seen in well between the two pontoons. The horizontal shaft is somewhat indistinctly seen on the right, with the rope belts connecting the vertical shafts. Through the door of the house may be seen the gasoline engine which furnishes the power. From the top of the house extends the frame-work which supports the awning.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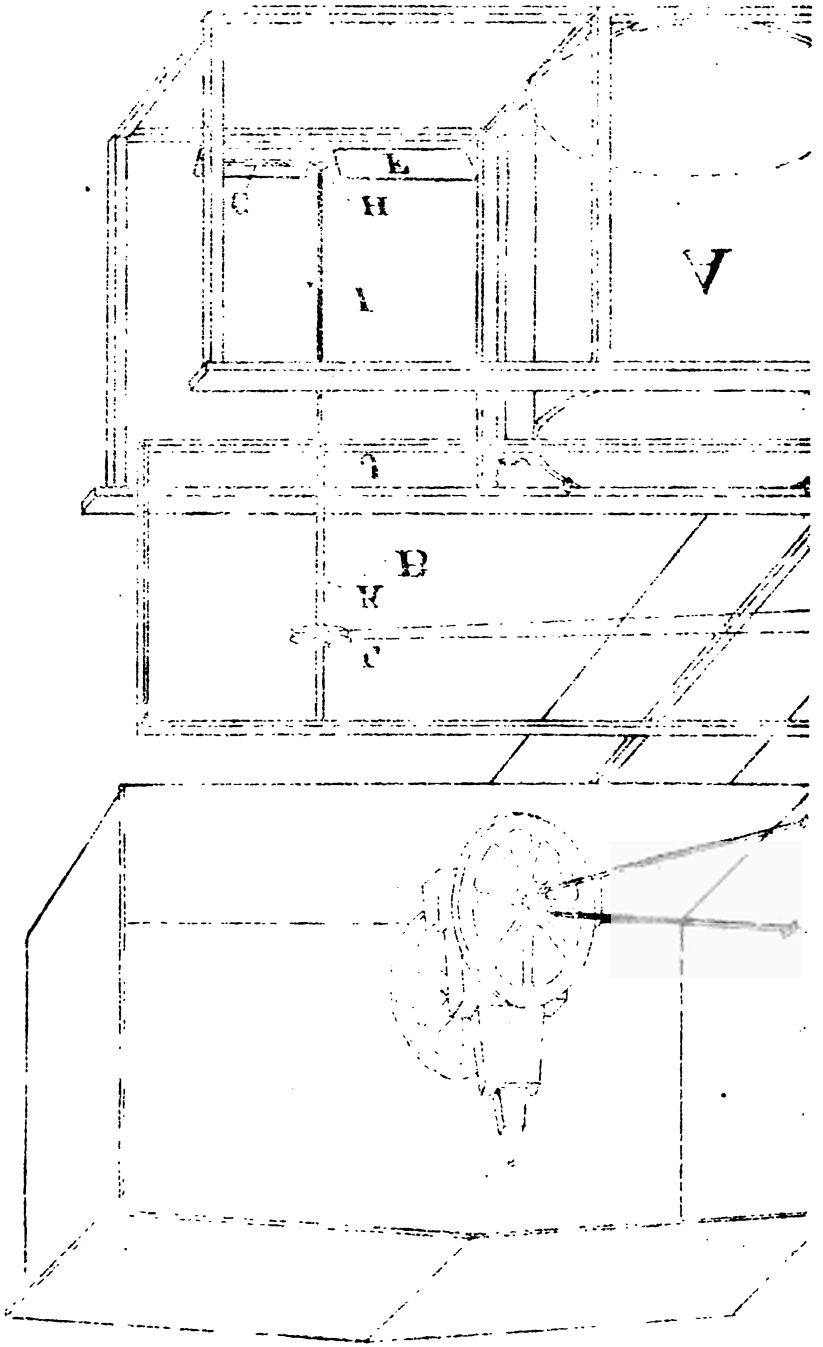
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An Account of the Experiments with this Newly-devised Apparatus.

It should be understood, in the first place, that the object was not to obtain the greatest possible number of "lobsterlings" in the fourth stage, but to ascertain how high a per cent. of the newly-hatched specimens could be reared to that stage under varying conditions.

Some of the fry were brought from the United States Fish Commission hatching-station, at Wood's Hole, by train, as there were at that time no boats available for transporting them, and were not in as good condition as those obtained in the season of 1900. The greater portion of those in our experiments, however, were hatched in the floating laboratory, at Wickford, from eggs obtained at Newport.

The following table gives the more important facts in respect to the several experiments:

Experiment number.	Date of Hatching.	Date of beginning experiment.	Number placed in bag.	Age when first IVs appeared.	Average age when IVs appeared.	Number in IV stage.	Per cent. reared to IV stage.	Remarks.
1	June 12	June 14	....	11 days	12 days	1418	.....	These were not counted in the early stage—the lot being stock for other experiments.
2	June 12	June 12	5000	.....	12–13 days	1110	20.22	Fry taken from lot number 1.
3	June 13	June 13	....	.....	13 days	1336	.....	
4	June 10	June 11	1000	13 days	15 days	347	34.70	Hatched at Wood's Hole and transferred.
5	June 13–15	June 14	2500	13 days	15 days	408	16.32	
6	June 13–15	June 15	2500	13 days	15 days	436	17.44	
7	June 13–15	June 17	2500	13 days	15 days	1004	40.16	These were from 2–3 days old when experiment began.
8	June 20	June 24	5000	.....	.....	....	.....	Experiment interrupted by an accident.
9	June 20	June 24	5000	10 days	11 days	971	19.42	These were four days old when experiment began; the percentage would have been higher if IVs had been promptly removed as soon as hatched.
10	June 20	June 25	5000	10 days	11 days	947	18.94	These were five days old when experiment began.
11	June 26 or 7	June 28	....	.....	.....	476	.....	From Wood's Hole.
12	June 26	June 28	2500	9 days	10 days	19	0.76	The experiment a failure through accident to bag.
13	June 26	June 28	1000	9 days	10 days	506	50.60	From Wood's Hole.
14	July 1?	July 2	1134	.....	.....	95	8.38	As this was the last lot and in poor condition, the agitation was not continued after the first five days.
						8974		(With the exception of numbers 4, 11, and 13, all were hatched at Wickford.)

The results of these experiments show that it is possible to rear the fry to the required fourth stage in comparatively large numbers and with a relatively small mortality. In the least successful experiment of those which were carried through, the per cent. which reached the fourth stage was sixteen; and of the others, the most successful yielded fifty per cent. In the experiments of previous years, the per cent. was probably not more than three or four at best, and usually only a fraction of one. The results, therefore, show conclusively that the principle of these experiments, namely, that the fry and their food should be kept constantly in motion, is correct.

Of course, there is room for further improvements, both in the details of the apparatus and in the manner of feeding and otherwise caring for the larvæ, and probably the proportion reared to the fourth stage can be considerably increased. On the other hand, we do not hesitate to express the opinion that were twenty per cent. carried to this stage, the industry would be benefited; in other words, that under natural conditions less than twenty lobsters out of every hundred live to reach this stage. If this opinion is correct, our results have already reached the stage of practical utility.

The experience of the past summer has indicated many cautions which should be considered in the conduct of the future experiments. The larvæ do not thrive well if they are too densely crowded in small enclosures. Twenty-five hundred was a large enough number for one bag. It is necessary to use a considerable amount of care also in transferring the lobsters from one car to another. They should, as far as possible, be dipped up with a considerable quantity of water and gently lowered into the new enclosure, so that they shall not come in contact with solid bodies or left to stand densely crowded together in a small dish.

In the previous report, mention was made of the effect of light upon the fry, and it has been found advisable to keep them in the shade, at least for the greater part of the time. At certain periods during the summer, there are great quantities of diatoms and

other small organisms, both plant and animal, which are caught in the meshes of the scrim bags, and there accumulate to such an extent that the circulation is often interfered with, and this, together with the fact that unused particles of food are apt to stick to the sides of the bags, renders it necessary occasionally to transfer the lobsters into clean bags; and it is found that this procedure apparently hastens the development.

Thus far the food has been, for the most part, finely-chopped clams, although other foods, such as shredded fish and finely divided lobster-liver, have been used. The food, in the shape of minute animal organisms, is often brought into the enclosures in great quantity by the constantly revolving propellers which create the current upward through the bottom of the bags. During the last few days in June, countless numbers of star-fish larvæ were thus carried into the bags and were kept there as in a trap, and on other occasions great quantities of small crabs and other crustacea were carried in in the same manner.

It was noticed, during the latter part of the season, that the shrimp which crowded together upon the outer surface of the bags, apparently having scented the food, were apt to get into the bags occasionally and play havoc with the lobster larvæ; and it is because of these shrimp that the percentage in some of the experiments was not very much higher.

Another caution which may well be mentioned is that of moving the lobsters as soon as they have moulted the third time and have reached the fourth stage. There is no necessity for their being held suspended in the current of water. They constantly endeavor to swim in the direction of the current or to cling to the sides of the bags. They are exceedingly voracious at this time, and it is much better to transfer them immediately to an enclosure with a sand bottom, or else put them overboard.

Although the bags in use last summer have given by far the best results yet attained, it would seem that more durable and economical apparatus could be devised for holding the fry, and experiments will be made in that direction the following season.

The Efficiency of the New Apparatus for Hatching Eggs.

It was intended, during the past season, to obtain the newly-hatched fry from the Wood's Hole hatching-station, but unforeseen conditions made this impracticable, and an attempt was made to hatch the lobster eggs with the same apparatus which was constructed to rear the fry. Accordingly, female lobsters were obtained from Newport in the early part of June, and the eggs were combed off in the ordinary manner and placed in the stirring-bags. When the propellers were set in motion, these eggs were gently swirled about and hatched out into very beautiful young lobsters. The device is simple, effective, and could readily be installed at any place where the water was fairly quiet. The proportion of the young which were hatched, and their condition, was, I believe, as satisfactory as in the case of those hatched by the elaborate apparatus used at many stations.

Experiments in Rearing Lobsters Beyond the Fourth Stage.

In addition to the problems stated on page 35 and dealt with in the previous chapters, there are two which pertain to the later development: First, is it possible to raise lobsters to maturity throughout the year in water which is so cold in the winter, is so fresh in the spring, and so warm in the summer as the more shallow estuaries of Narragansett Bay; second, what is the rate of growth and the conditions which influence it?

In the fall of 1900, about fifty lobsters which had been reared at the house-boat were put into a car which had gravel-stones in the bottom, galvanized screens at the sides, and a tight wooden cover. The car was lowered to the bottom of the channel, near Point wharf, at Wickford, in about ten feet of water, and left there over winter. In the latter part of December it was examined and several specimens taken out—the remainder being left and the car returned to the bottom. The temperature was very low at this time and it was necessary to break ice to reach the locality where the car had been left. The lobsters themselves were very sluggish

in their movements, and could readily be picked up with the hand. Those which were removed on this occasion were exceedingly lively as soon as they were brought into somewhat warmer water.

On the 10th of May the box was lifted from the bottom and transferred to a float attached to the house-boat, where the lobsters were kept during the rest of the summer, within eighteen inches of the surface. The density of the water underwent sudden and great variation during the months of May and June, so that at low tide on certain days it was very fresh. For instance, on May 11th and 13th, it was only 1.0095, the temperature being 59° and 53° Fahrenheit. At low tide the density was 1.020 within two or three days of these dates. These figures show a great difference in the density, nevertheless, the lobsters seemed to suffer no inconvenience, and there was very little mortality during the whole summer.

When the box was taken up on May 10th, twenty-three lobsters were found alive and in good condition, and their measurements are given on page 49. Subsequently, on June 12th, all of the gravel was removed from the car and several specimens which had escaped detection before were found and the number was increased to twenty-eight. These were transferred to a new car like the preceding one, and there remained until November 8th, when they were again put down at the bottom of the channel for the winter. During this time several specimens were preserved or died through accident. During the summer they were fed on clams and fish, but did not receive the best of care in the busy part of the season. They shed frequently, and many of the cast skins were secured and preserved.

The following measurements show the actual length in millimetres and inches on several dates during the summer; and it is clear, from comparing these measurements, that the yearling lobsters reared under apparently the same conditions show remarkable variations in size and characteristics, which were pointed out in a previous report as very noticeable in the young lobsters from two weeks old to five months:

MEASUREMENTS.

On May 10th.		On June 12th.		On August 22d.		On November 7th.		
mm.	in.	mm.	in.	mm.	in.	mm.	in.	
40	1 5/8	41	1 5/8	49	2	69.85	2 3/4	
41	1 5/8	42	1 5/8	55	2 1/8	73.02	2 7/8	
41	1 5/8	42	1 5/8	57	2 1/4	79.37	3 1/8	(Male)
42	1 5/8	44	1 3/4	57	2 1/4	79.37	3 1/8	
43	1 5/8	47	1 7/8	60	2 3/8	82.55	3 1/4	
44	1 3/4	47	1 7/8	62	2 1/2	82.55	3 1/4	
45	1 3/4	47	1 7/8	65	2 1/2	85.72	3 3/8	(Male)
45	1 3/4	49	2	65	2 1/2	85.72	3 3/8	
47	1 7/8	49	2	68	2 3/4	88.90	3 1/2	(Male)
47	1 7/8	49	2	69	2 3/4	95.25	3 3/4	
48	1 7/8	50	2	70	2 3/4	95.25	3 3/4	
48	1 7/8	50	2	70	2 3/4	98.42	3 7/8	(Male)
50	2	51	2	70	2 3/4	101.60	4	
50	2	52	2	70	2 3/4	107.95	4 1/4	
52	2 1/8	52	2	75	3	111.12	4 3/8	(Male)
53	2 1/8	52	2	80	3 1/8	111.12	4 3/8	
53	2 1/8	54	2 1/8	80	3 1/8	120.65	4 3/4	(Male)
53	2 1/8	55	2 1/8	81	3 1/8			
54	2 1/8	55	2 1/8	82	3 1/4			
55	2 1/8	56	2 1/4	82	3 1/4			
56	2 1/4	57	2 1/4	85	3 3/8			
58	2 1/4	57	2 1/4	86	3 3/8			
58	2 1/4	58	2 1/4	95	3 3/4			
		59	2 3/8	110	4 3/8			
		63	2 1/2					
		64	2 1/2					
		66	2 5/8					
		68	2 5/8					
Av. 48.8	2	53.4	2 1/8	70	2 3/4	92.30	3 1/2	

This experiment of keeping the lobsters over winter gives a definite affirmative answer to the question whether the temperature and density of the water will permit the rearing of lobsters in the upper part of the Bay. And it is obvious that this question is one of prime importance, for it shows that it is not necessary

for the lobsters to go into deep water during the winter, and this fact brightens the prospect of propagating lobsters in our Bay, either within artificial enclosures or free.

The second question—what is the rate of growth of the lobster up to the legitimate length for commerce?—is one which is very often asked. The effect of the enforcement of the laws prohibiting the capture of short lobsters depends, of course, upon the rapidity with which lobsters reach maturity. Although the question cannot at present be answered definitely, the experiments at Wickford have furnished considerable data in regard to it. They show that the rate of growth varies enormously in different individuals reared in the same car, under apparently the same conditions. On September 15, 1900, when the lobsters caught that year were about three months old, the average length was a little less than one and a half inches. The larger specimens were about one and three-quarters inches. In November, 1901, when they were about one year and five months of age, the largest measured about five inches, and the smallest not over two and three-quarters inches. And yet both large and small specimens were in healthy condition. The question at once arises—how do we know the rate of growth in the cars fairly represents the rate in the free state of nature? The healthy condition of many animals and plants whose normal growth is known, which have been purposely or accidentally reared in the cars, indicates that at least many of the conditions would resemble closely the natural conditions. But the more direct evidence is the following: A number of lobsters caught at Wood's Hole in small traps in the middle of the summer were not larger than the average of our lobsters when one year old. The ones which were caught must have been at least one year old, inasmuch as the eggs are hatched only in the early summer, and these were altogether too large for the crop of that year. It is certain, therefore, that lobsters reared in the cars were, at the end of the year, as large as many of those which had grown in their natural environments. The experiments in rearing lobsters, therefore, give a fair idea of the rate of growth during the first

year and a half, but the later growth is at present merely a matter of conjecture. It would seem that the length of nine inches would not usually be attained before the third year. And it is practically certain that the variation in growth is so great that it will never be possible to tell the age of a large lobster from its length.

In conclusion, we may say that although the experiments in lobster-culture at Wickford have been carried on only two seasons, they yielded satisfactory results and have solved some of the problems of fundamental importance in lobster-propagation. These results would, we believe, warrant attempts at lobster-culture on a considerably larger scale and further investigation of some of the questions which are still obscure.

X. The Efforts of the Commission to Prevent the Illegal Taking of Short Lobsters.

At the January session of the General Assembly, 1901, your honorable body passed the following act:

AN ACT FOR THE BETTER PROTECTION OF THE LOBSTER FISHERIES.

It is enacted by the General Assembly as follows:

Section 1. Every person who catches, takes, or has in his possession any lobster less than nine inches in length, measuring from one extreme of the body to the other, exclusive of claws and feelers, or any female lobster bearing eggs or from which the eggs have been brushed, shall forfeit for every such lobster five dollars, one-half thereof to the use of the complainant and one-half thereof to the use of the state; but a person catching or taking any such lobster and immediately returning the same alive to the water from which taken shall not be subject to such penalty.

Sec. 2. All lobster pots, cars, and other contrivances used for the catching or keeping of lobsters shall be plainly marked with the name or names of the owner or owners. And every person who shall not have his lobster pots, cars, and other contrivances so marked shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

Sec. 3. There shall be between the fifteenth day of November and the fifteenth day of April next succeeding a close time, during which time it

shall be unlawful for any person to set or keep, or cause to be set or kept, within any of the waters of this state, any pots or nets for the catching of lobsters or to take any lobsters during such close time. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 4. No person shall be allowed to set or keep, or cause to be set or kept, within any of the waters of this state, any pots or nets for the catching of lobsters who has not had his home and residence in this state for the period of one year next preceding the time of his catching such lobsters. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 5. Every person, except the commissioners of inland fisheries and their deputies, who shall lift or raise any pot or net set for the catching of lobsters, without the permission of the owner or owners thereof, shall be fined ten dollars for each such offence.

SEC. 6. Possession by any person of any lobsters between the fifteenth day of November and the fifteenth day of April next succeeding shall be *prima facie* evidence before any court of competent jurisdiction that such lobsters were taken in violation of this act; and every such person shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 7. The commission of inland fisheries shall appoint at least two deputies, whose duties shall be the enforcing of the provisions of this act. Each of said deputies appointed as aforesaid shall be by virtue of his office a special constable and, as such deputy, may without warrant arrest any person found violating any of the provisions of this act and detain him for prosecution not exceeding twenty-four hours. Said deputies shall not be required to enter into recognizance or become liable for costs.

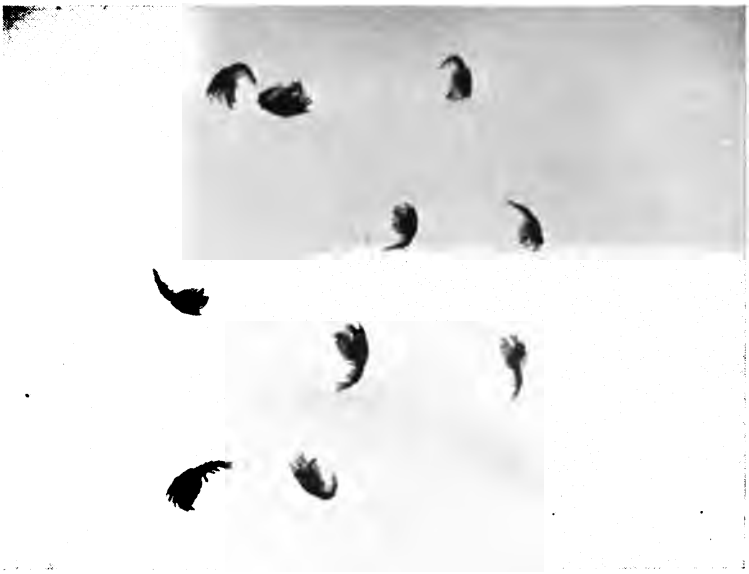
SEC. 8. Each of said deputies shall have the right to go upon any boat or vessel used in the catching or transporting of lobsters and search for and seize any such lobsters that they believe to have been taken in violation of any of the provisions of this act.

SEC. 9. Fines incurred under any of the provisions of this act shall inure one-half thereof to the use of the complainant and one-half thereof to the use of the state.

SEC. 10. The several district courts shall have concurrent jurisdiction with the common pleas division of the supreme court over all offences under this act, and to the full extent of the penalties therein specified; parties defendant, however, having the same right to appeal from the

1. Lobsters in the first stage, one day old, hatched at the United States Fish Commission, Wood's Hole, Mass. Natural size.

2. Lobsters in the second stage, that is, having moulted or shed their skins once; about four days old; reared artificially at Wickford, Rhode Island. Natural size.



3. Lobsters in the third stage, about eight days old; reared at Wickford, Rhode Island. Natural size.

4. Lobsters in the fourth stage, having moulted three times; about two weeks old; reared at Wickford, Rhode Island. Natural size.

5. Lobsters in the fifth and sixth stages; reared at Wickford, Rhode Island. Natural size.

6. Lobster in the seventh stage; reared at Wickford, Rhode Island. Natural size.

7. Lobster seven weeks old; reared at Wickford, Rhode Island. Natural size.

8. Lobster one year and three months old, which died in the process of shedding. The skin has been shed from the head and claws, but still remains attached to the abdomen or tail. The shrunken condition of the soft claws may be observed and compared with the casts of the claws. This is from a photograph and is natural size.

sentences of said district courts as is now provided in law in other criminal cases.

SEC. 11. Sections 8, 9, and 10 of Chapter 173 of the General Laws, entitled "Of Certain Fisheries," and also Chapter 316 of the Public Laws, and all acts and parts of acts inconsistent herewith are hereby repealed.

SEC. 12. This act shall take effect from and after its passage.

Your commission has endeavored to enforce the law in regard to the taking of short lobsters and egg lobsters. Several deputies were appointed to act in this capacity—two of them residing in Newport, one in Little Compton, and one at Narragansett Pier. It has been the policy of the commission, acting through their deputies, to prevent the violation of the law, as far as possible, without antagonizing the interests of the fishermen, and consequently arrests have been made and prosecutions instituted only in those cases where this expedient seemed to be absolutely necessary. It is the opinion of the commission, obtained from conversation with the deputies, lobster dealers, and the fishermen themselves, that the attempt to enforce this measure has been as successful as could be expected, and that very many thousand short lobsters have been returned to the water.

XI. PREPARATION OF AN EXHIBIT FOR THE PAN-AMERICAN EXHIBITION.

At the request of the Pan-American Commission of the State of Rhode Island that the Rhode Island Commission of Inland Fisheries should be represented in the exhibition, a series of collections was especially prepared to illustrate the results of the systematic investigation which your commission has conducted on the natural history of the marine food animals of the State.

The exhibit was neatly installed in the Agricultural Building as a State exhibit. Much credit is due to Mr. A. G. Delaney, who had immediate charge of the installation. The expense of installing and of returning the collection was borne by the Pan-American Commission, to whom as a whole, and to Mr. George N.

Kingsbury in particular, we are under obligation for many courtesies throughout the whole progress of the exhibition.

I. The first section of the exhibit consisted of a series of specimens of the soft-shell clam, mounted in cases under glass, and showing the rate of growth of the clam as determined by the investigations of Kellogg and Mead during the last three years. The specimens exhibited varied in size from those hardly visible to the naked eye up to those whose shells measured over three inches in length. The special interest in this exhibit consisted in the illustration of the variation in the rate of growth among clams reared in different parts of the Bay, and under various other different conditions; the size which the clam attained at maturity, the size of the clam when a year old, and the size of the clam, reared under favorable conditions, at the age of a year and a half.

II. The next series illustrated the growth of the scallop from about two months old to the age of eighteen months. The principal interest in this collection is the demonstration of the so-called line of growth in the scallop—a mark which appears clearly upon the shell when the scallop has attained the age of one year—and which therefore is an important feature, because, at a glance, one may be sure whether scallops taken for market are less or more than one year old. This, again, is exceedingly important, because the scallop breeds only once, and that when it is about one year old. This demonstration, therefore, is of practical importance in connection with the efforts which are being made to stop the illegal catching of scallops for market before they have had a chance to breed.

III. This series of specimens was prepared to illustrate the experiments of this commission in conjunction with the United States Fish Commission in the artificial propagation of lobsters. It consisted of a series of specimens of the growing lobster, beginning with the fry which had been newly hatched and were less than a day old. The subsequent stages illustrated by these specimens represented a large number of the successive stages up to the time the lobster is a year and a half old. The more important

of these stages is the so-called fourth stage, attained by the lobster fry after it has shed its skin three times. This stage is important because it represents the period when the young lobster is able to protect and defend itself very much better than in the earlier stages; and it has been the effort of the United States Fish Commission and your commission to rear the lobsters in large quantities to this fourth stage. In the subsequent stages illustrated by the specimens, the important features are the average rate of growth and the difference in the rate of growth of different individuals. Several other specimens illustrated the manner of the shedding of the skin of the lobster. This collection of specimens was exhibited in a new solid preserving medium—the formula for which has not yet been published. The value of this medium is that it makes it possible to suspend the specimens at any level in the exhibition jar, without the use of threads or strings.

IV. This section consisted of a series of specimens of the star-fish—the most effective and dangerous enemy of the oyster and the scallop—and was arranged to show the rapidity with which the star-fish attains its growth under favorable conditions, and also to show the great variation which may take place in the growth of the star-fish according to different conditions of its food-supply, etc. It also contained specimens illustrating the peculiar character of the larval star-fish, which are destroyed in such immense numbers by the menhaden, and the manner of setting the larval star-fish and its transformation into the form of the adult.

V. Several specimens of oysters were shown in this section, for the purpose of illustrating the rate of growth of the oyster. The specimens showed the average size of oysters for the first four years of their growth, and some exhibits of extreme age from twelve to fifteen years. These specimens were furnished by the Kickemit River Oyster Company, and the age of the large specimens was vouched for by one who had planted them from twelve to fifteen years ago.

VI. In this section there were exhibited three interesting

fishes: 1st, a fine specimen of the tarpon, occasionally caught in Rhode Island; 2nd, a large specimen of the small-mouthed black bass; and 3rd, a painting, made from life, and in the possession of the United States Fish Commission, of the newly discovered tile fish, which is abundant off the coast of Rhode Island, in the water of about one hundred and fifty fathoms, at the edge of the Gulf Stream. The tile fish has been recently introduced into the markets by the United States Fish Commission, and the history of its discovery, disappearance and reappearance, and the account of its economic value, has been given in the report of this commission for 1900.

VII. This section of the exhibit consisted of a large relief map of Narragansett Bay and the surrounding shore, made by the commission, to show the configuration of the sea bottom, etc. The model was constructed from accurate government charts, which give very numerous soundings, and the territory represented in the model extends beyond the mouth of the Bay nearly as far as Block Island. The location of the fish-traps and the leased oyster grounds of the Bay for the year 1900 are indicated upon the map.

VIII. In addition to these special exhibits, a list of the special papers representing the investigations of the commission since 1898 was presented for the benefit of those who wished to learn more fully the results which the exhibit was intended to illustrate. The list is as follows:

The report of 1898 contains:

1. A preliminary report on the star-fish.

The report of 1899 contains:

2. A record of the dredging of the United States Fish Commission steamer "Fish Hawk," in Narragansett Bay.
3. Investigations of the red-water plague, which destroyed multitudes of fish and crustacea during the fall of 1898.
4. Special report on the star-fish.
5. Life-history of the common clam (*Mya arenaria*).
6. Report on the tile fish (*Lopholatilus chamæleonticeps*).

The report for 1900 contains:

7. Observations on the soft-shell clam.
8. List of fishes known to inhabit Narragansett Bay.
9. List of diatoms found in the water over the clam, mussel, and oyster beds at Wickford, R. I.

The report for 1901 contains:

10. Observations on the soft-shell clam (second paper).
11. Habits and life-history of the scallop (*Pecten irradians*).
12. Further observations on the red-water plague, with notes on its occurrence elsewhere.
13. Additions to the list of fishes known to inhabit Narragansett Bay, with remarks on rare specimens recently caught.
14. Habits and growth of young lobsters, and experiments in lobster-culture.

The exhibit was well received by visitors, and was awarded a gold medal under Division VII, Fish and Fisheries. Several of the collections are now displayed at the rooms of your commission in the State House.